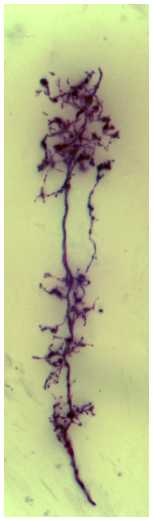
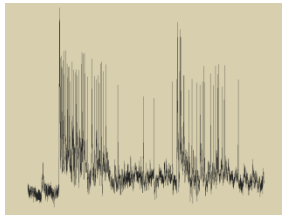
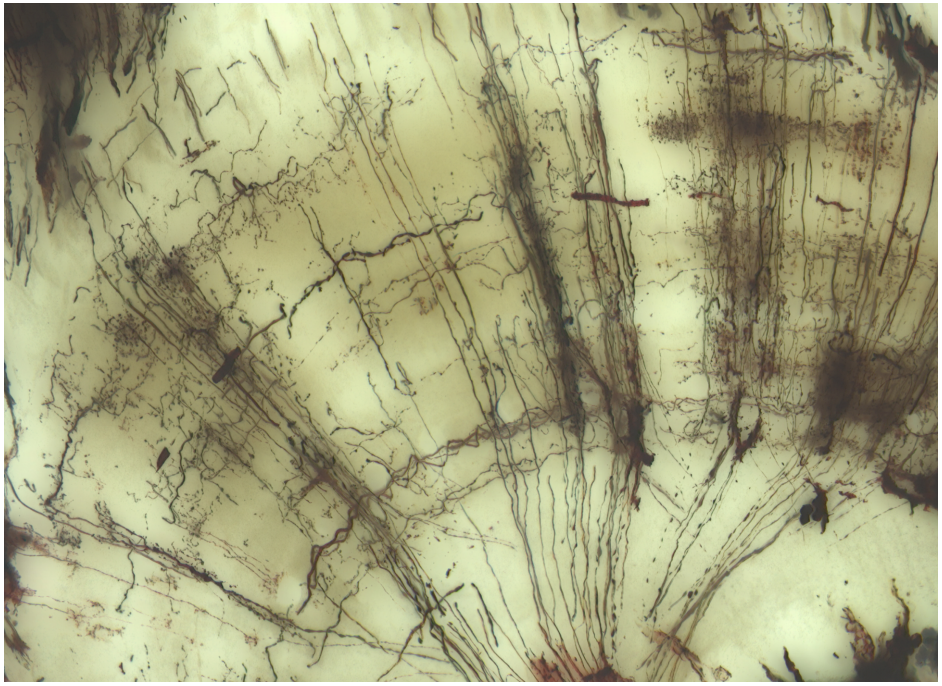
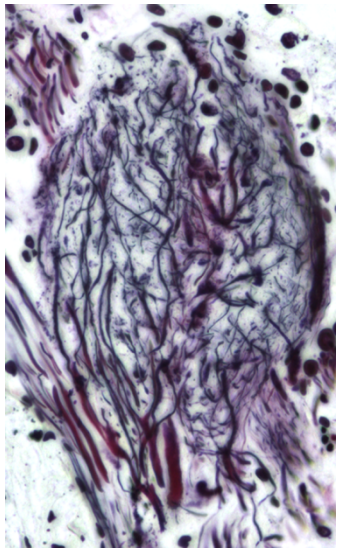


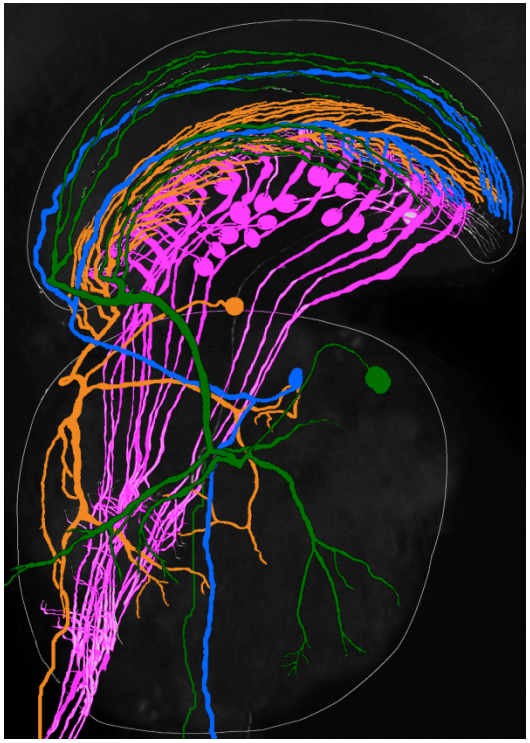
A peek into a crab´s optic lobes that support motion detection, visually-guided behaviors and memory.



Julieta Sztarker







Universidad de Buenos Aires-CONICET
Argentina

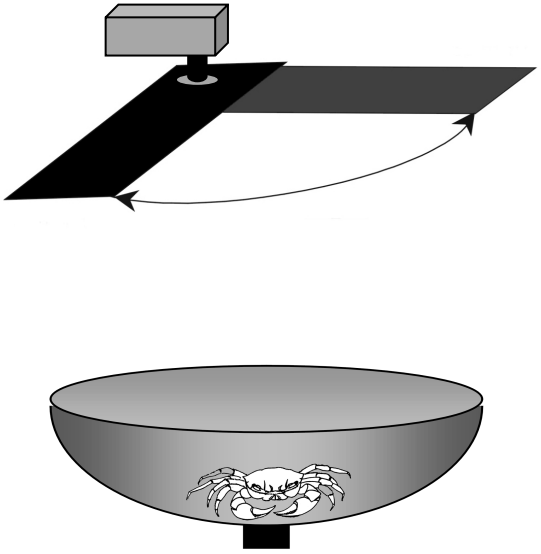
The crab *Neohelice granulata*

1 cm

Semiterrestrial (estuarine) crab. Very adapted to changes in salinity, humidity and temperature.

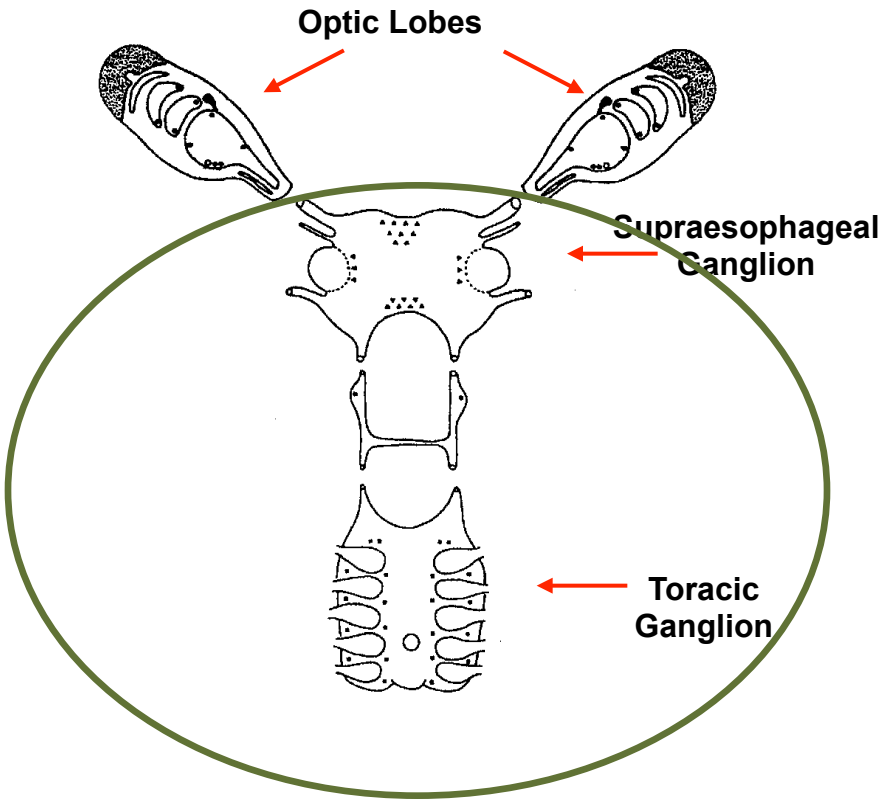
The mudflat

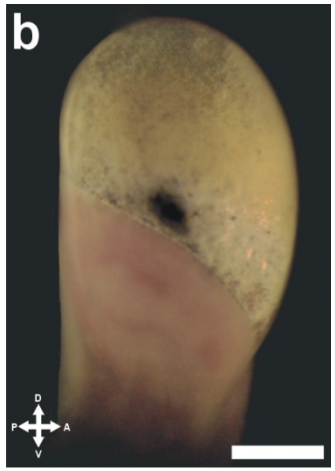
In the lab: Visual danger stimulus (VDS)

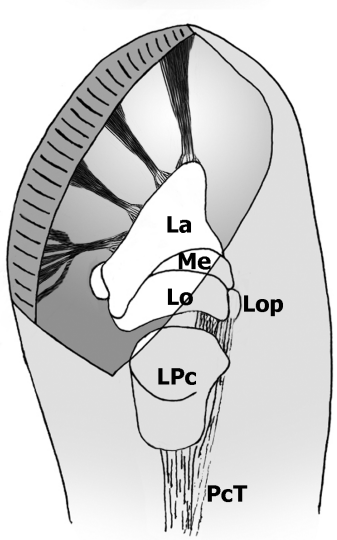


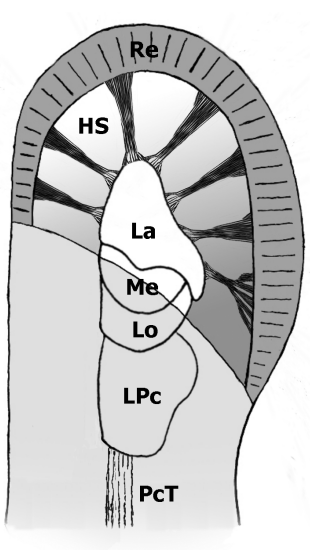
Videos: Fernando Locatelli

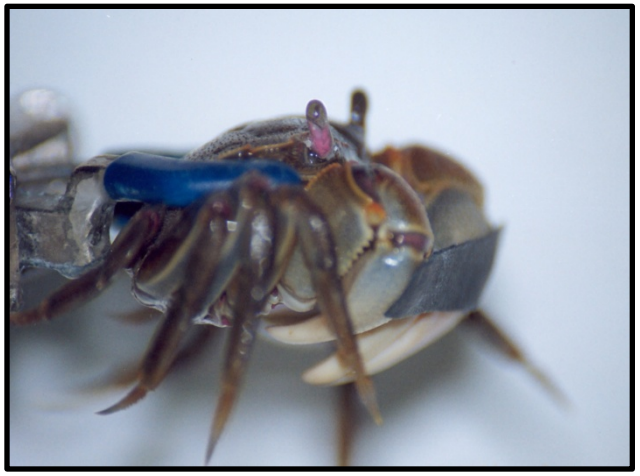
Central nervous system



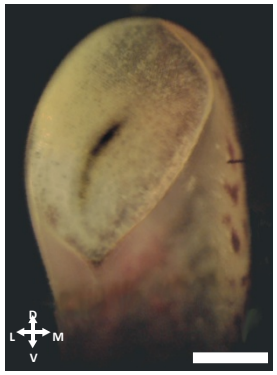


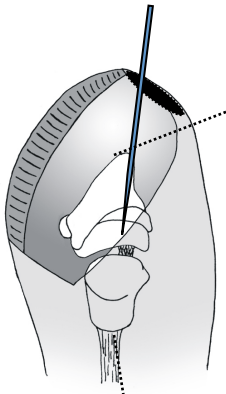




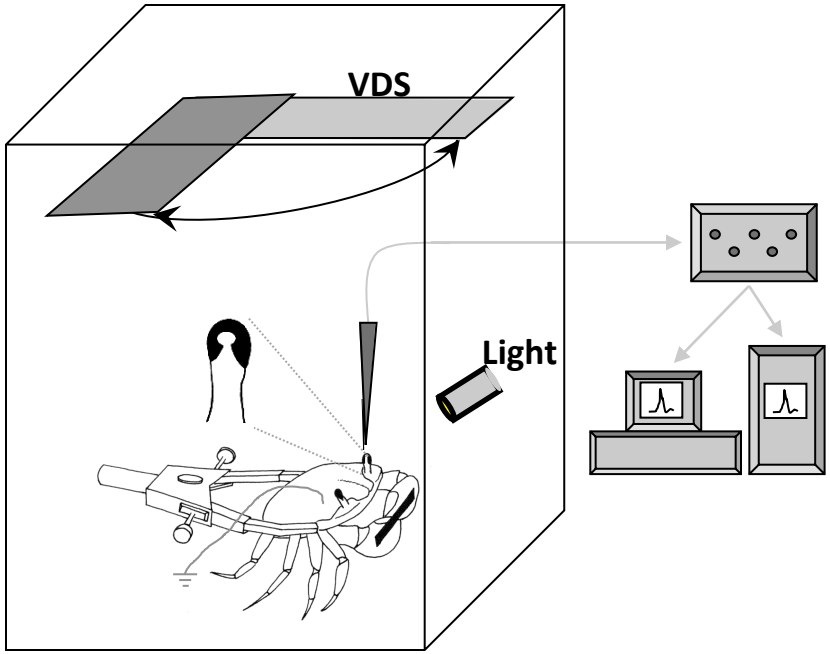


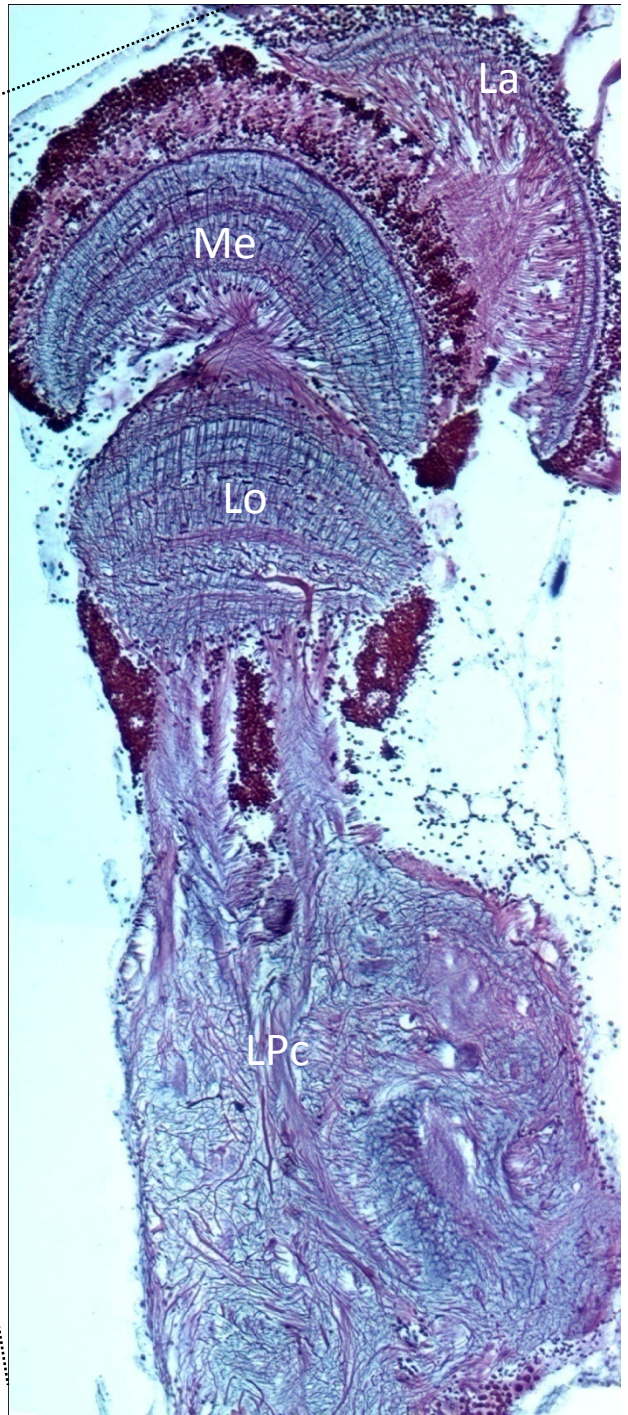
Mechanic stability





Easy access to the brain in the intact animal

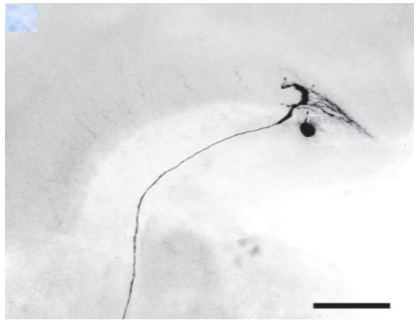


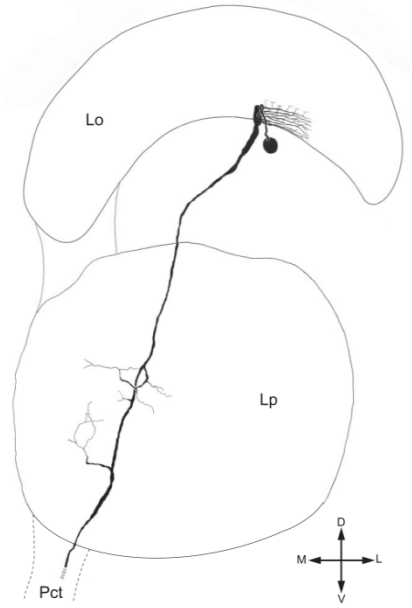


Lobula giant neurons (LG)

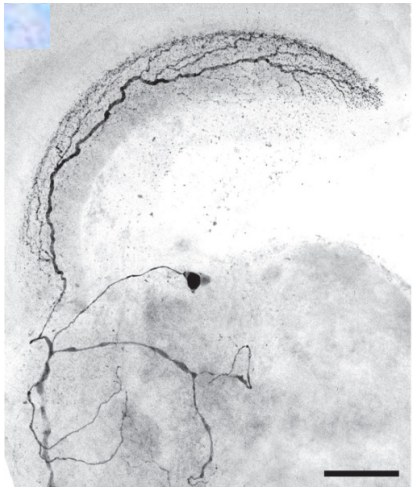
Monostratified

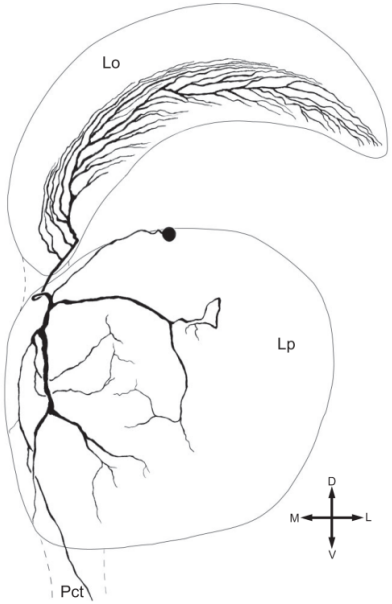
MLG1





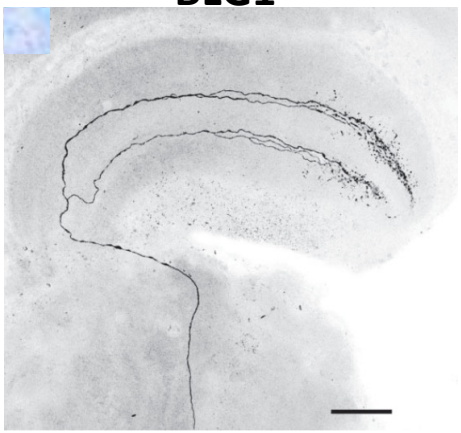
MLG2

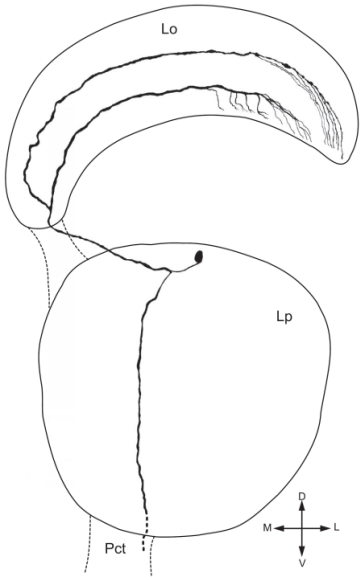




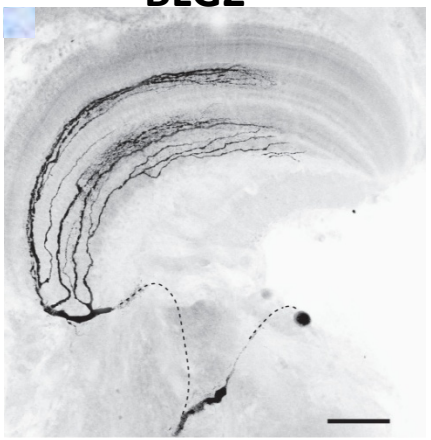
Bistratified

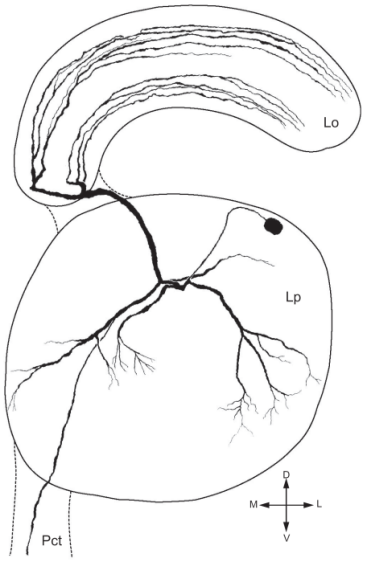
BLG1





BLG2

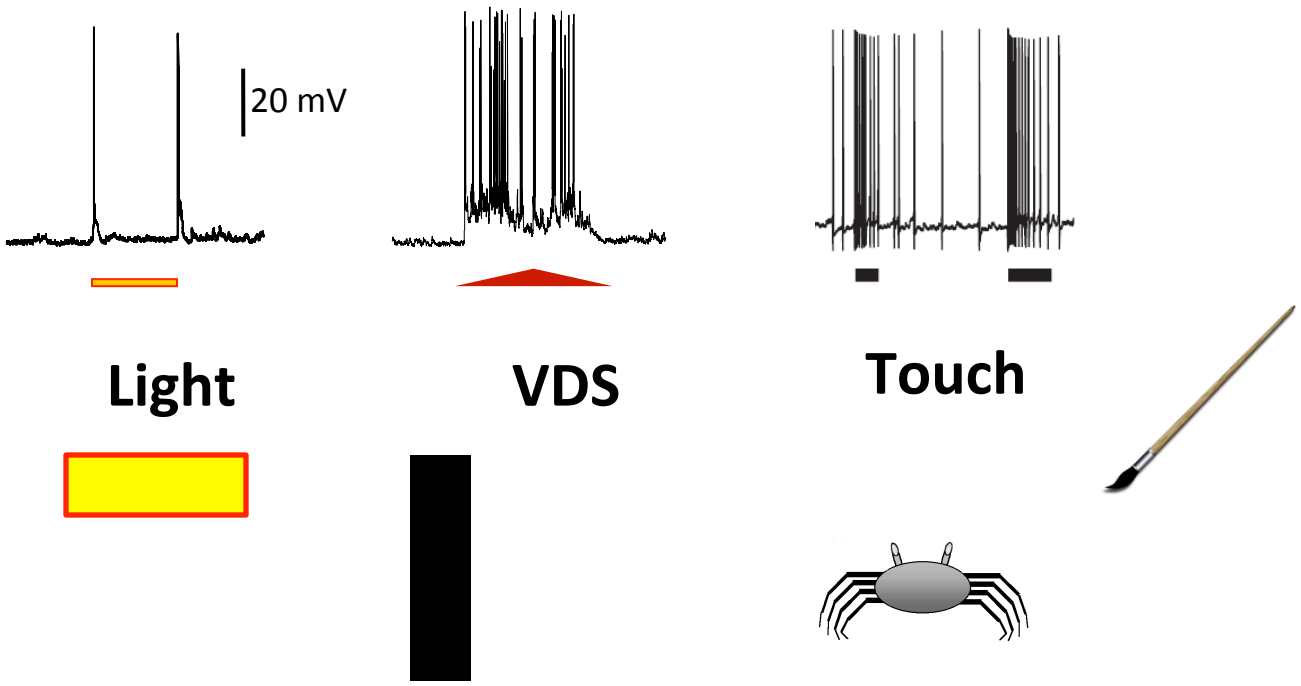




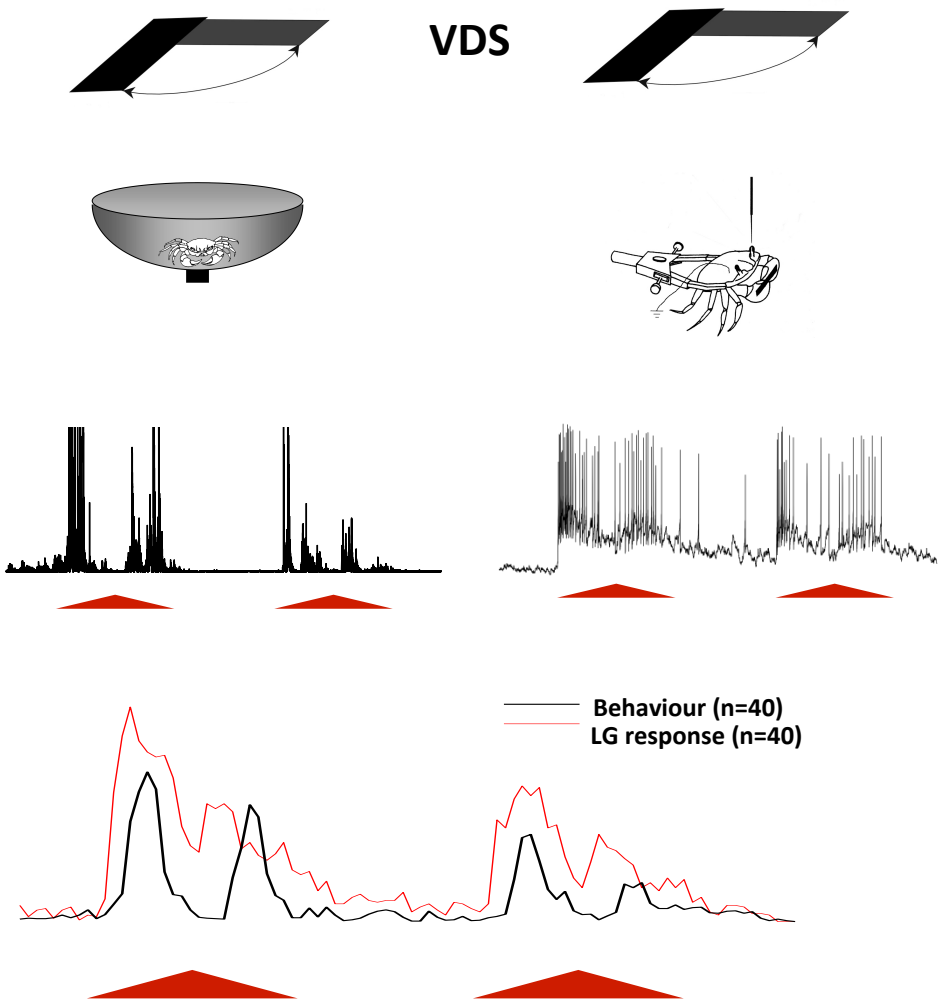
Medan et al., 2007

LG Properties

- **Preferential response to moving objects. Most of them process mechanical information as well**



Berón de Astrada and Tomsic, 2002

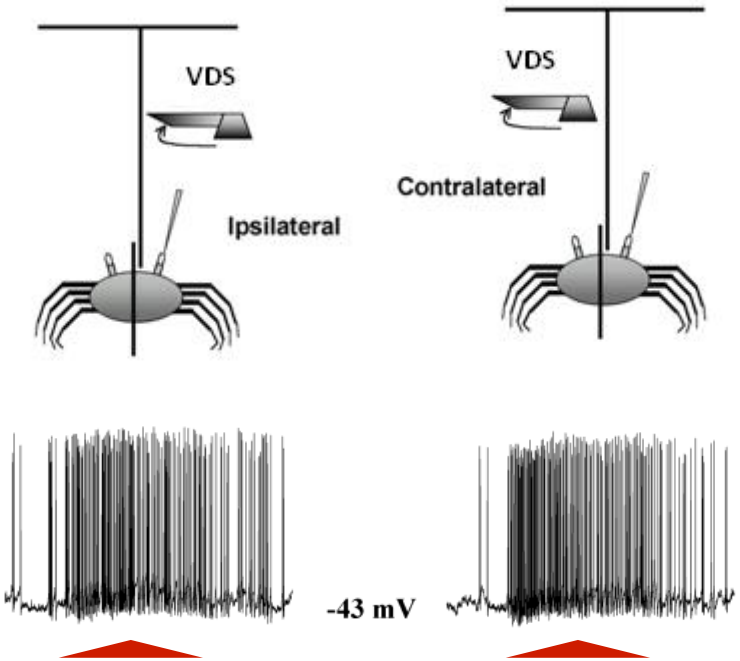


LG response anticipates escape response in 120 msec

Tomsic et al, 2003. J Neuroscience

LG Properties

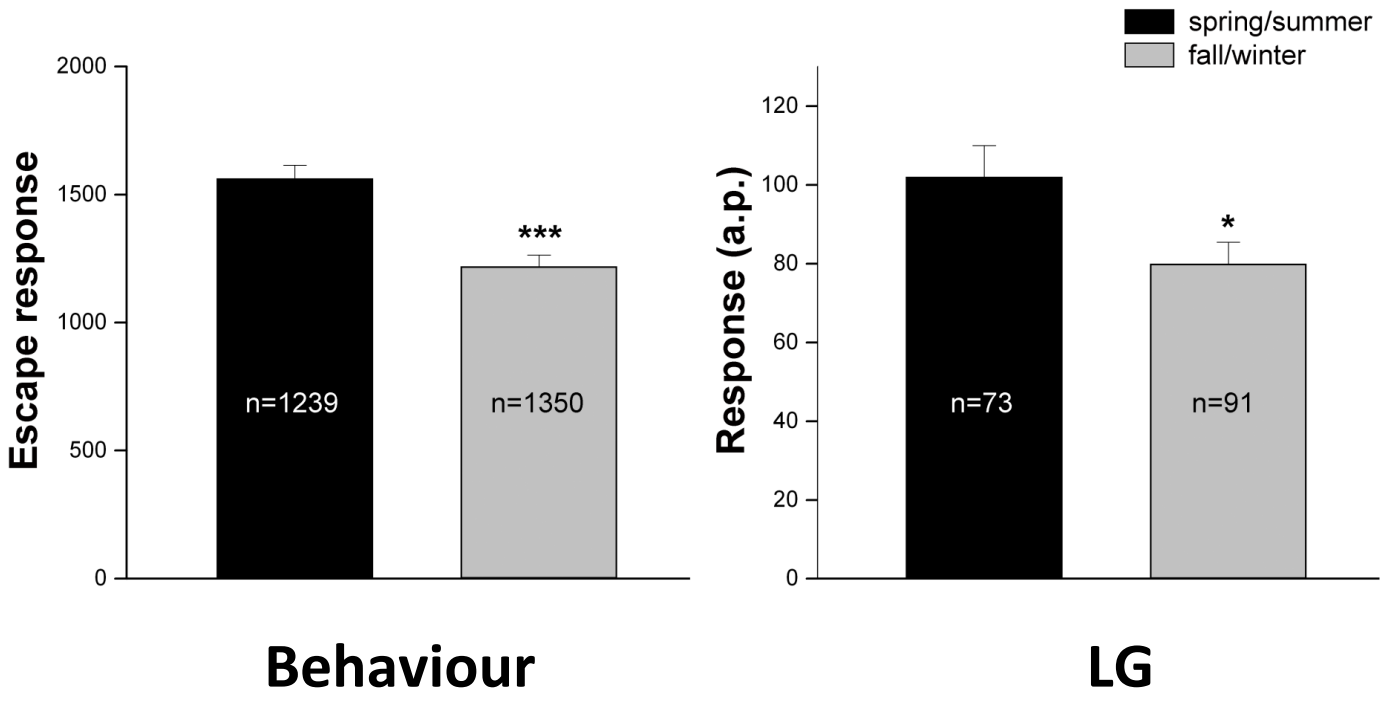
- **Binocular visual integration: ipsilateral and contralateral responses are very similar**



Sztarker & Tomsic, 2004 J Comp Physiol

LG Properties

- **Reflect the seasonal changes observed at the level of escape response**



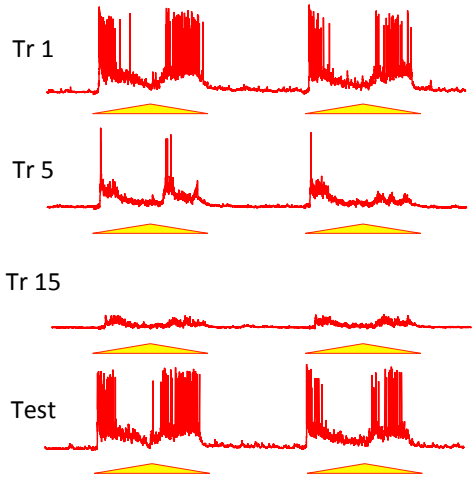
Sztarker & Tomsic, 2008 J Comp Physiol

LG Properties - Learning

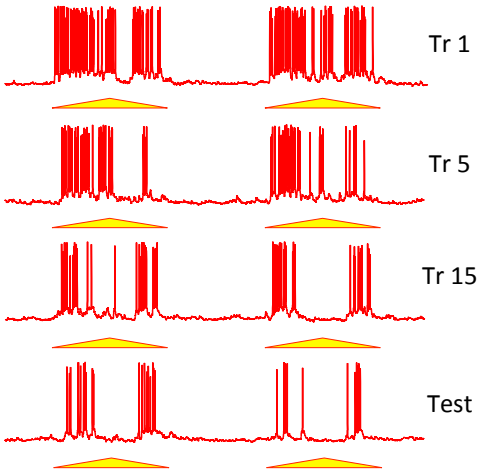
- **They reflect the learning-induced changes in crab's behavior induced by a high frequency (massed) training that generates a short memory (minutes) and by a spaced training that produces a long-term memory (days).**

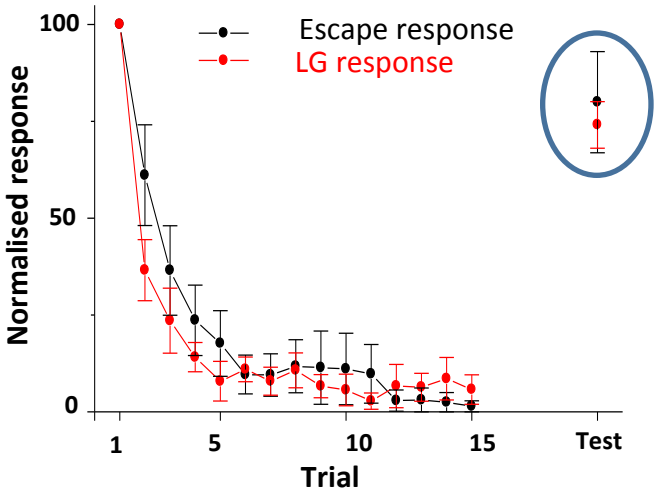
Short-term memory (test: 15 min post-training)

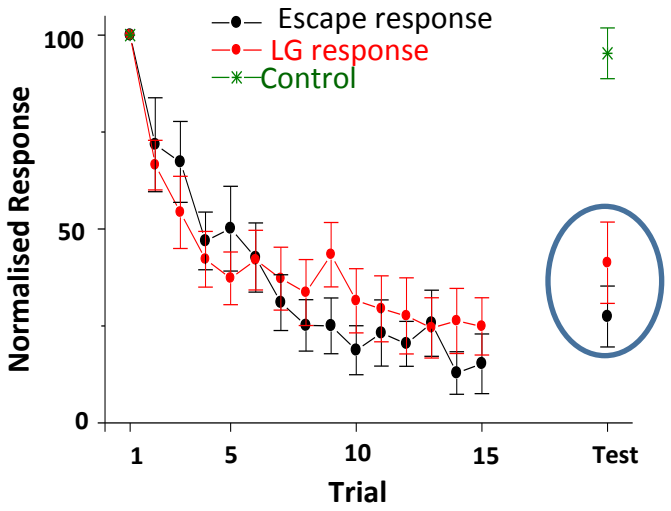
massed training



spaced training

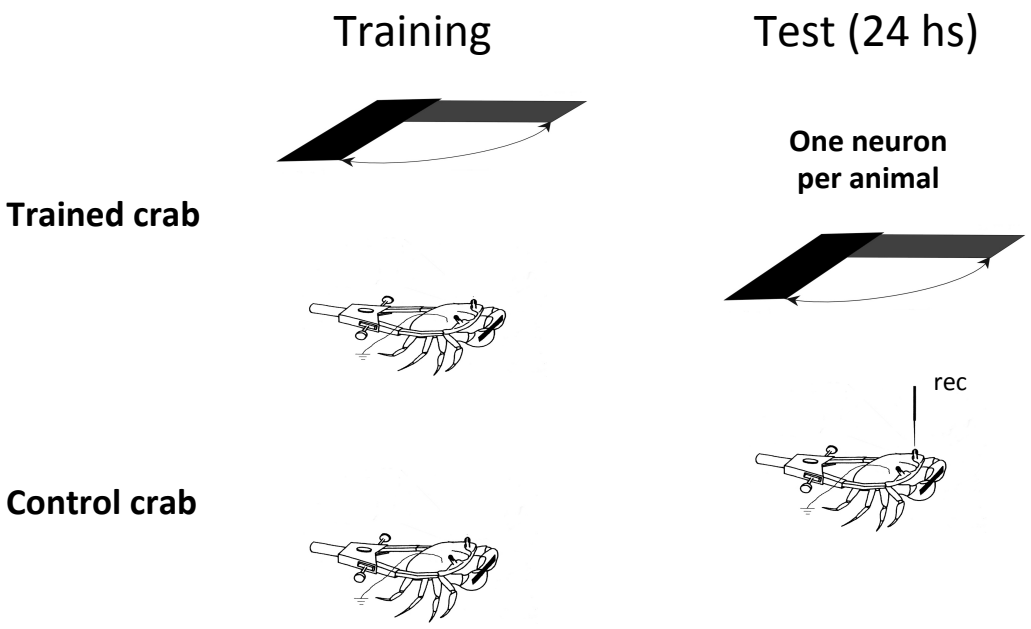


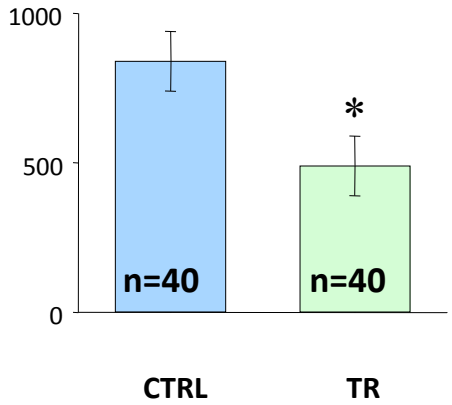


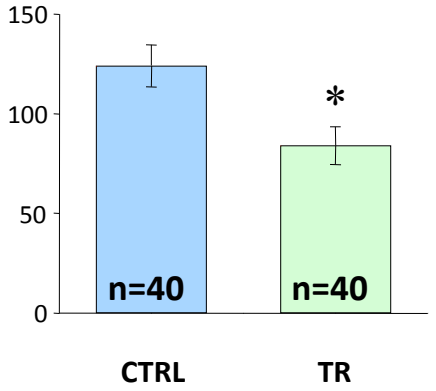


Tomsic et al, 2003. J Neuroscience

Long-term memory (test: 24 hs post-training)





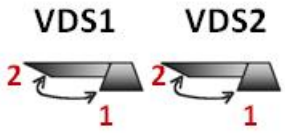


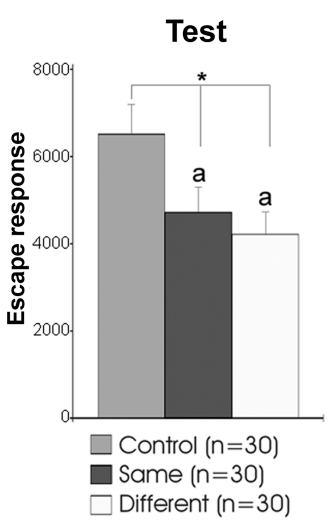
Tomsic et al, 2003. J Neuroscience

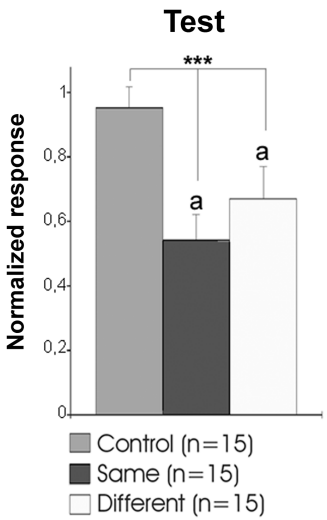
LG Properties - Learning

Support crab's ability for generalisation and stimulus specificity produced by spaced training

Changes in position

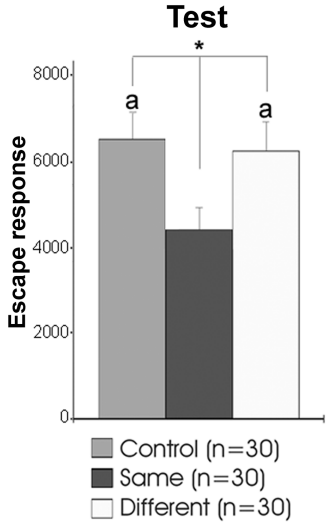


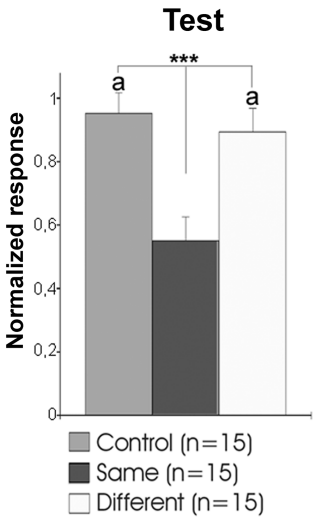




Behaviour **LG response**

Changes in direction





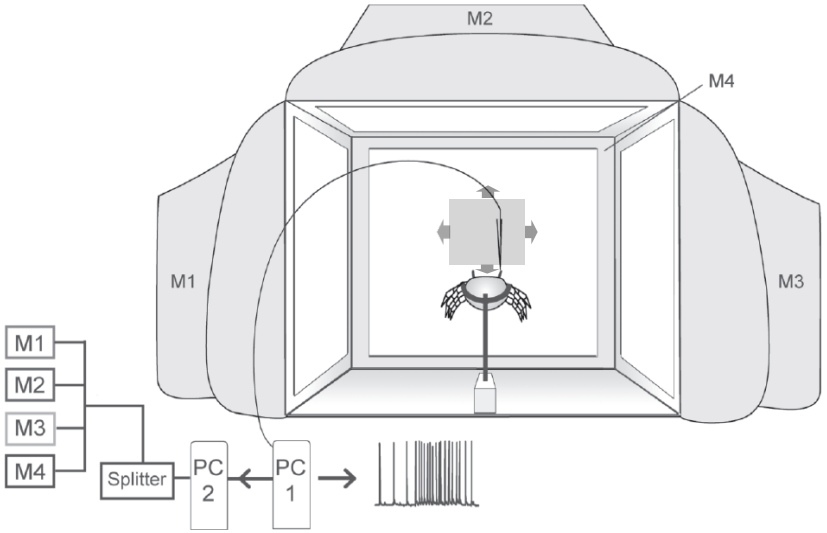
Behaviour **LG response**

Generalisation

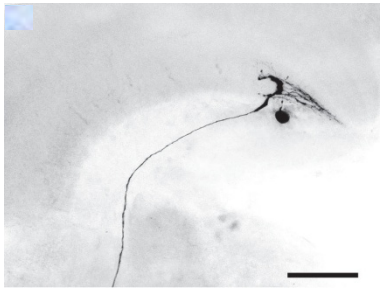
Stimulus specificity

Sztarker & Tomsic, 2011 J Neurosci

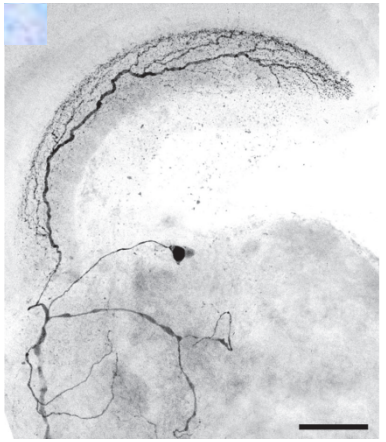
Looming detection

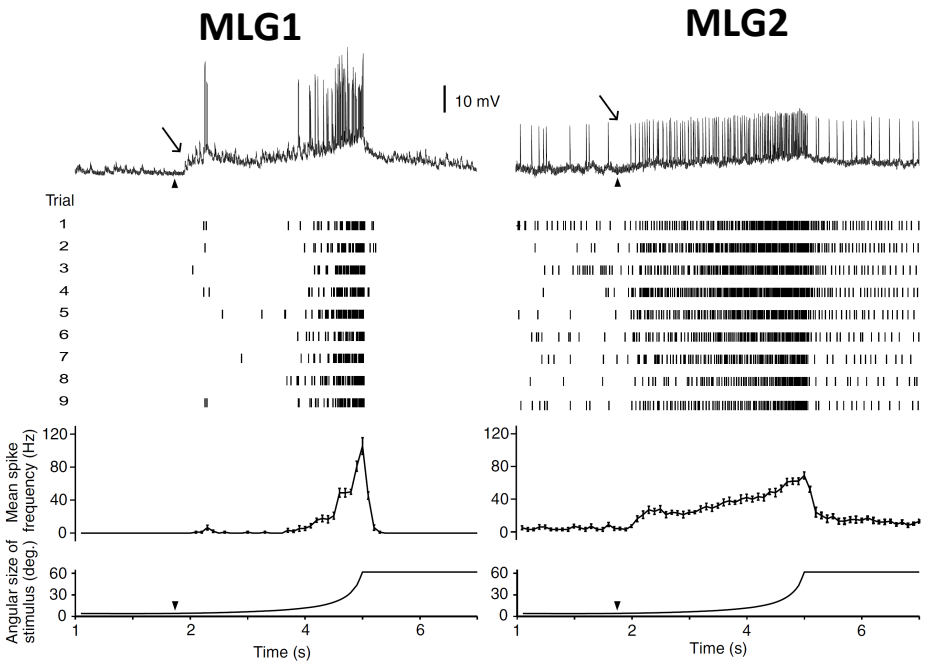


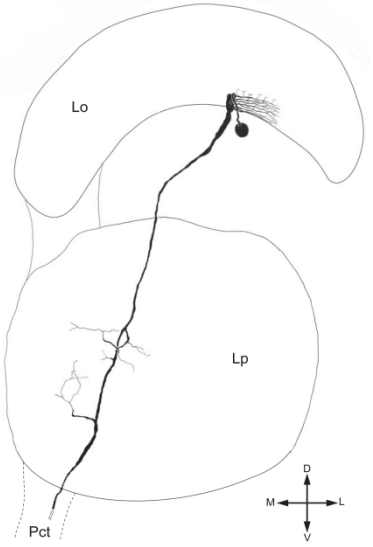
MLG1

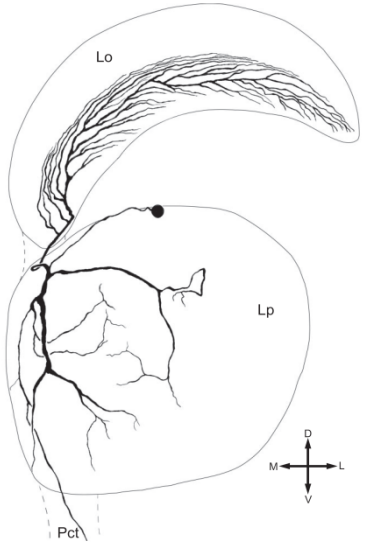


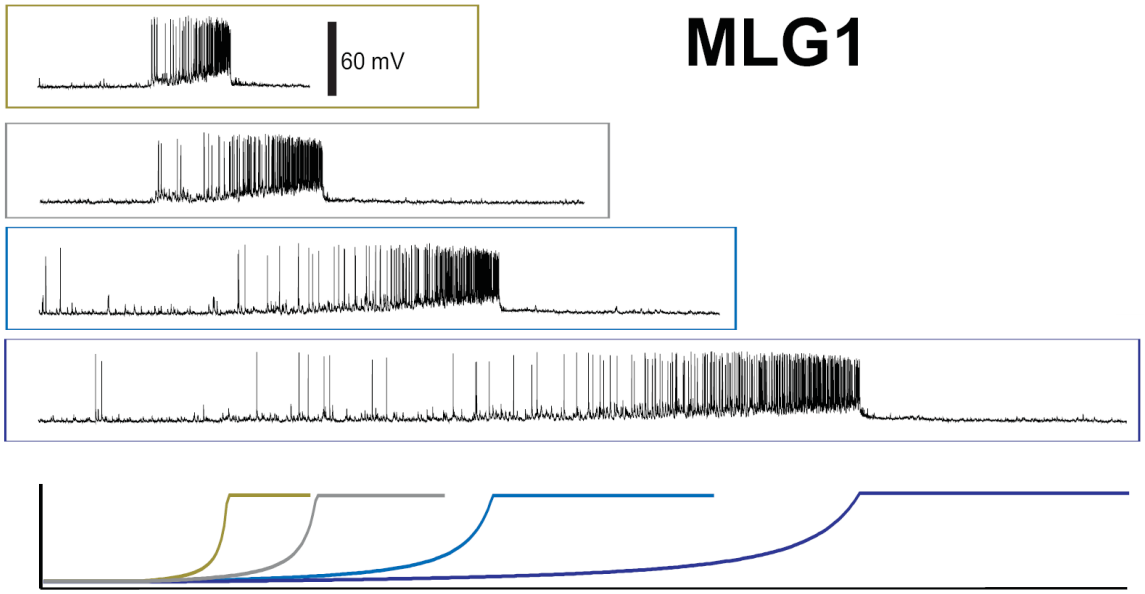
MLG2

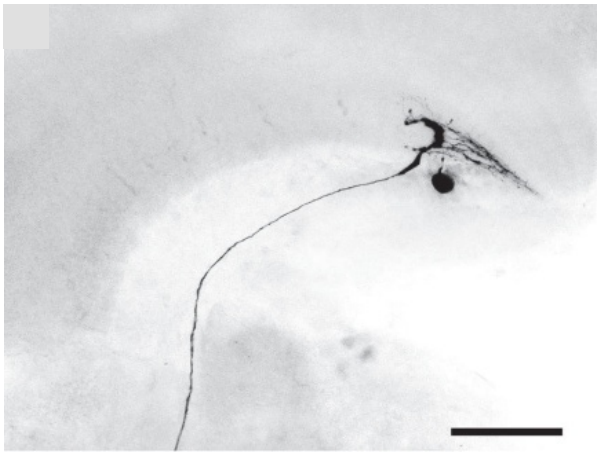


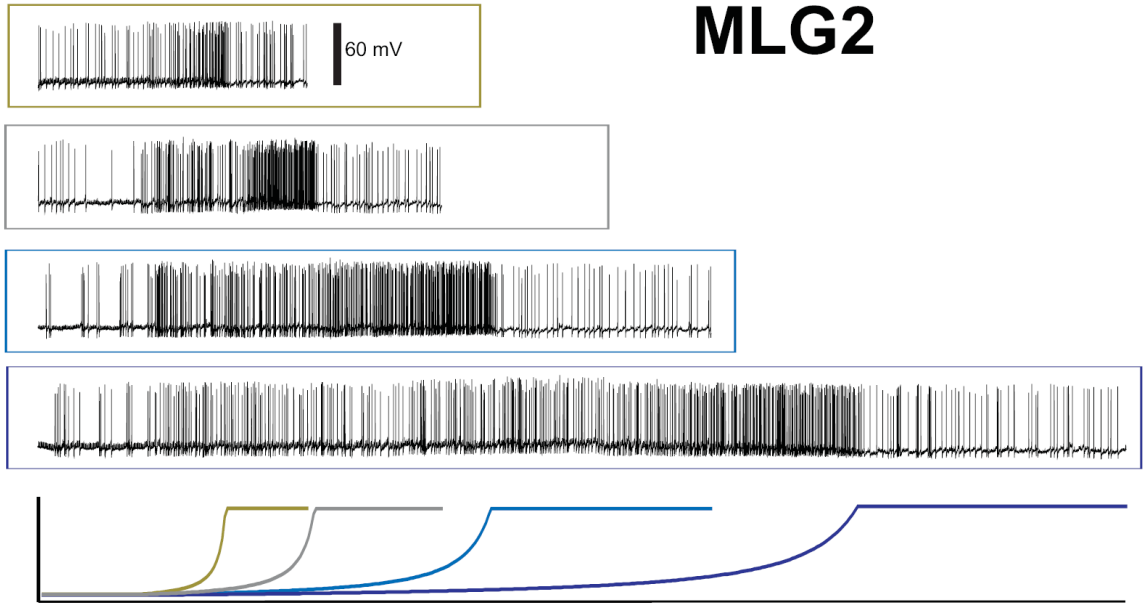


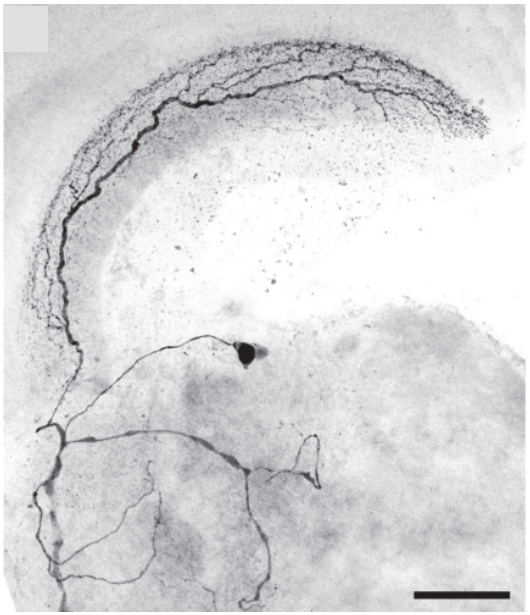






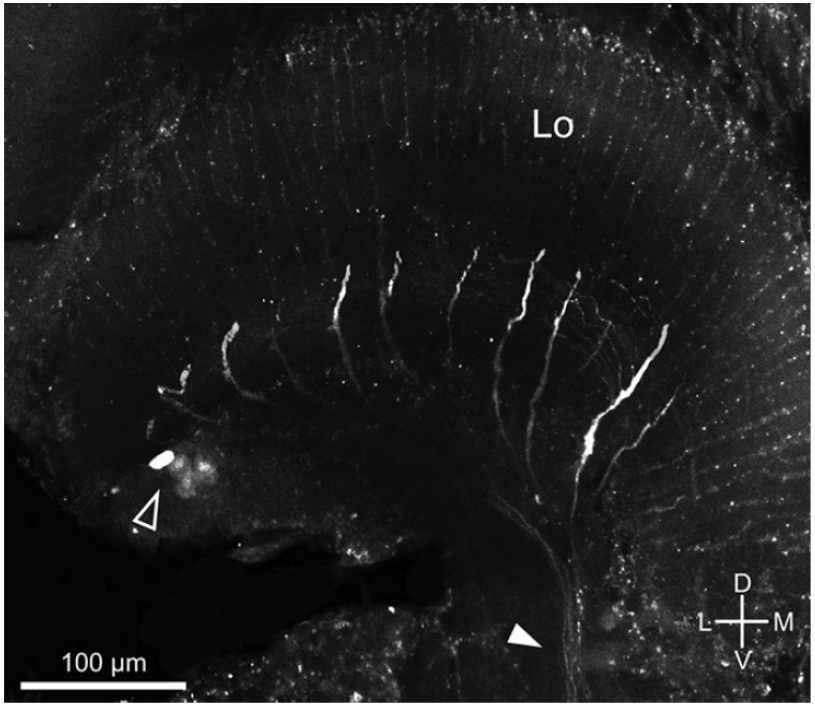


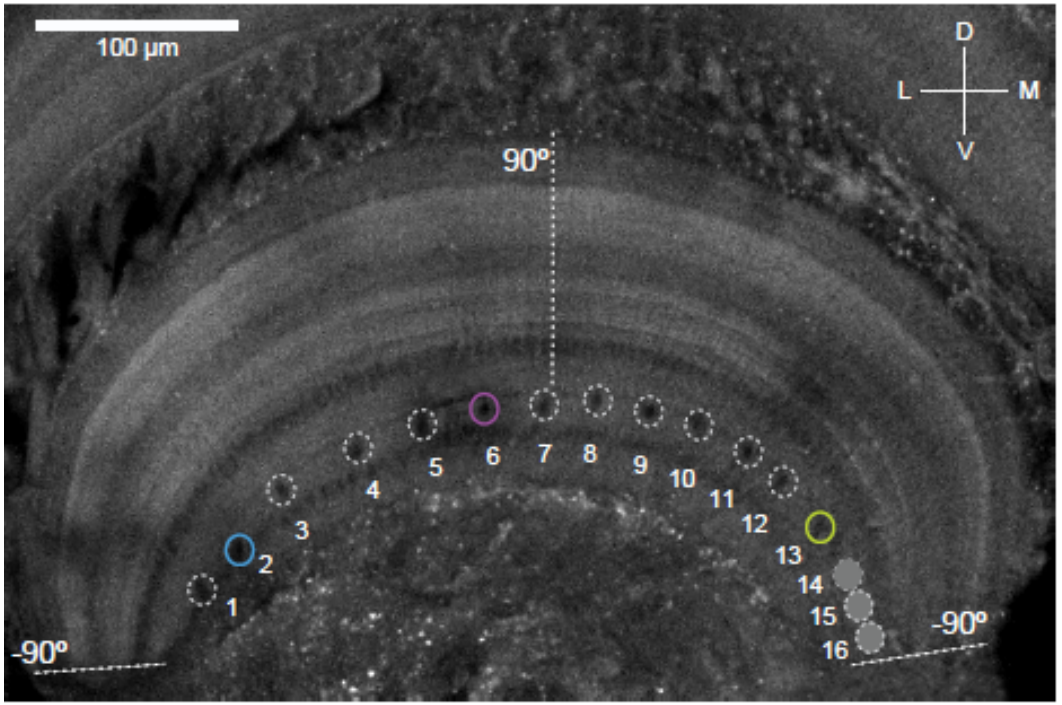


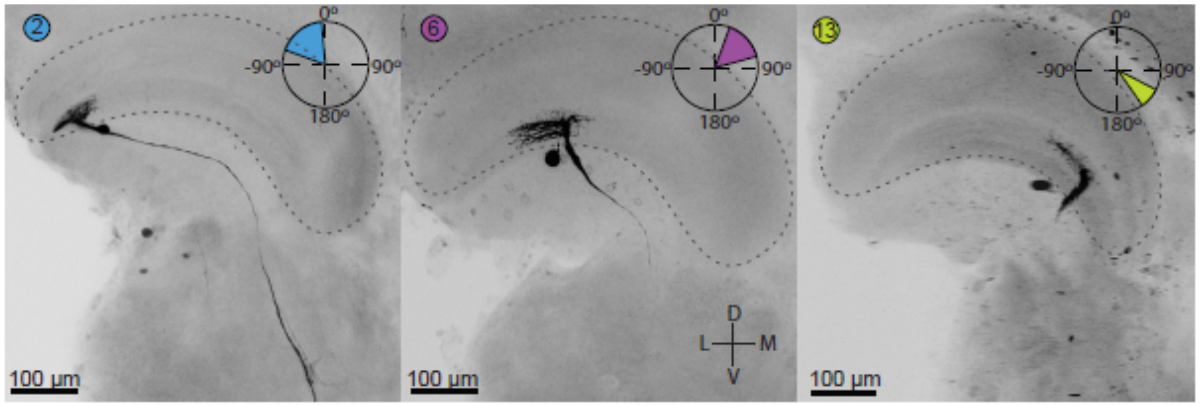


Oliva and Tomsic, 2014; 2016

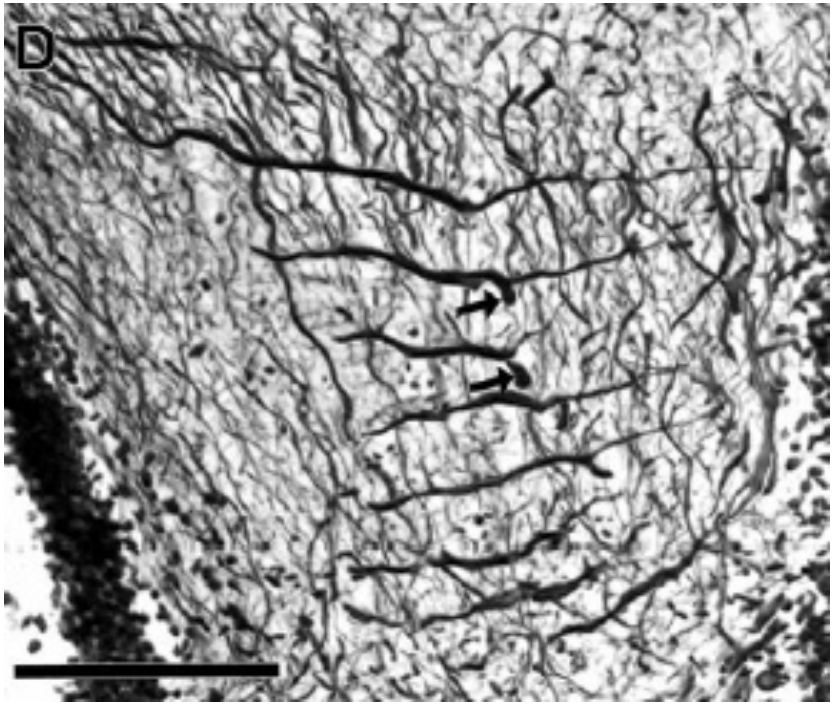
16 MLG1 elements

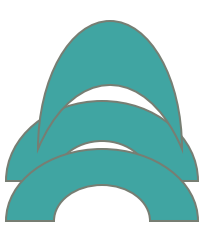


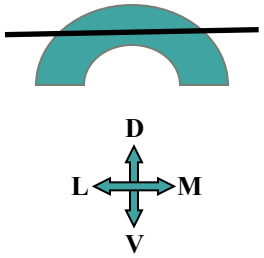


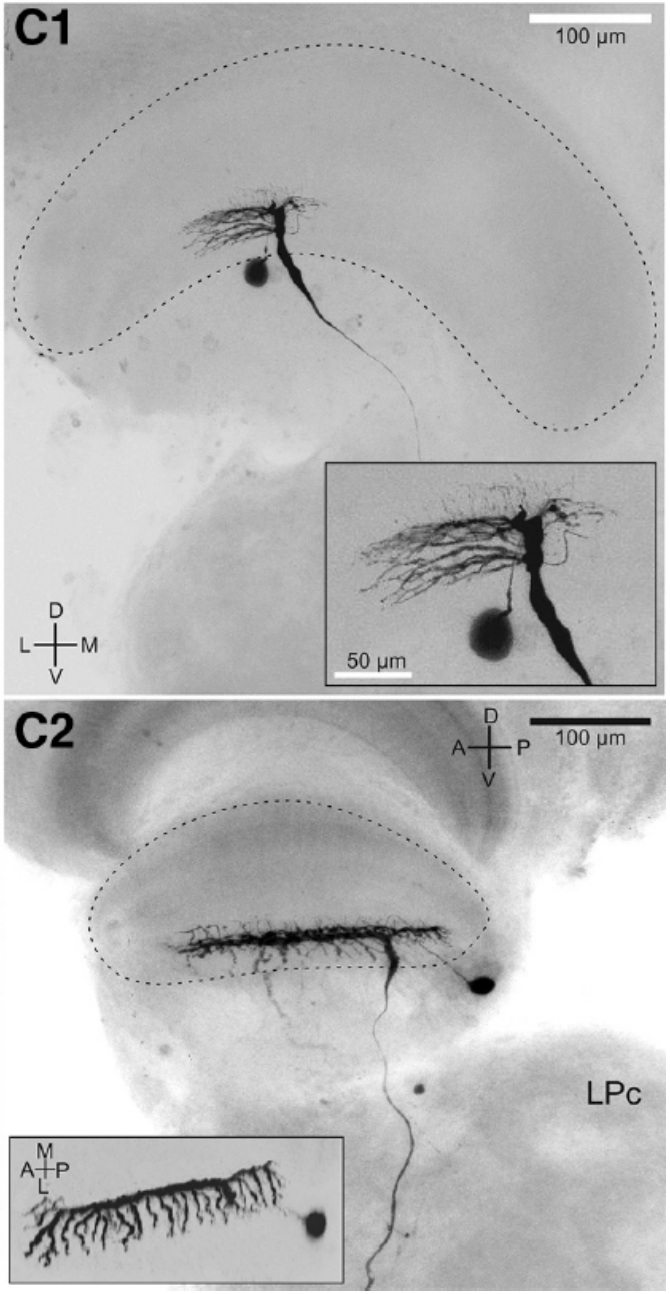


Medan et al. 2015 J. Neurosci



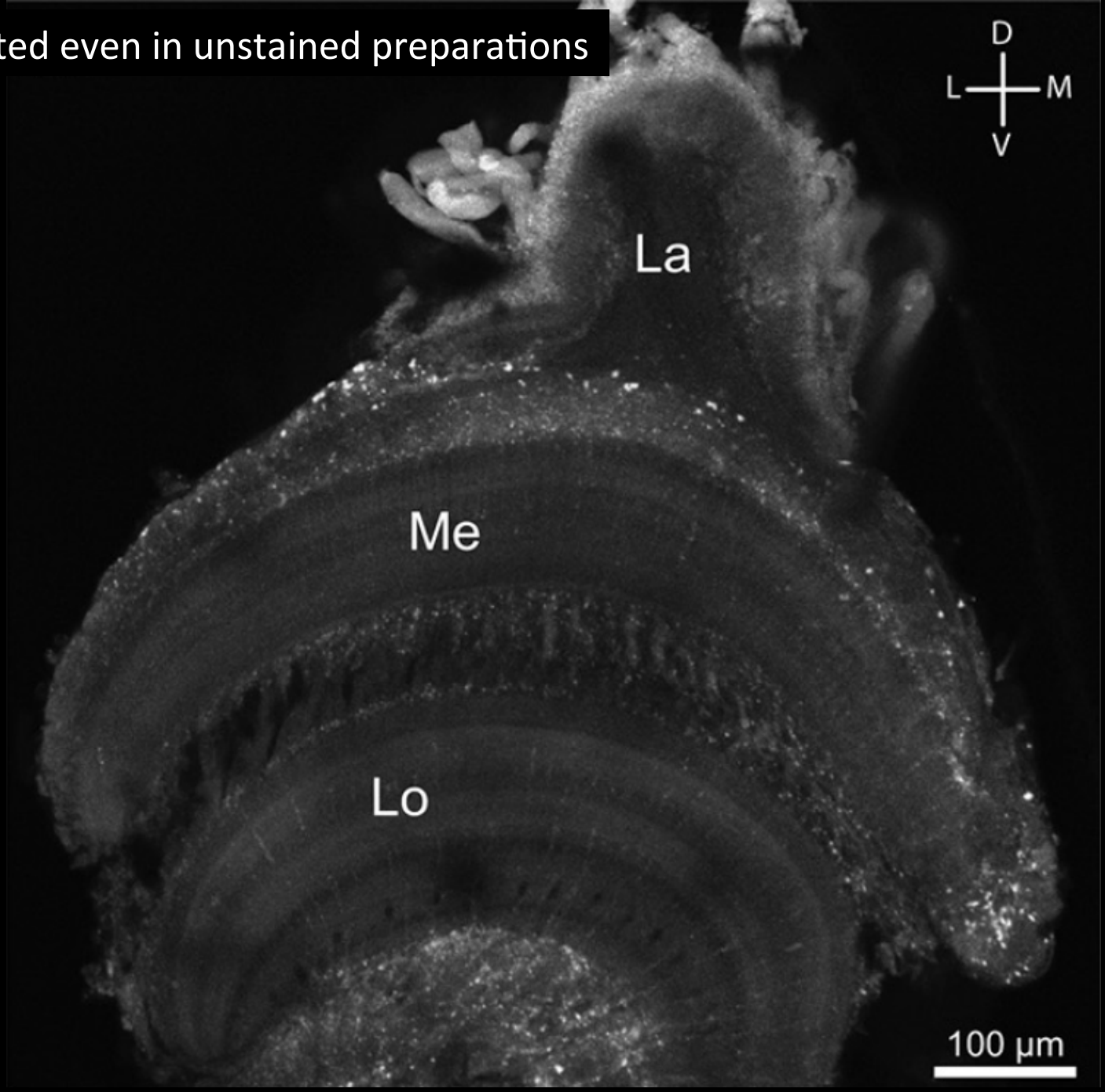




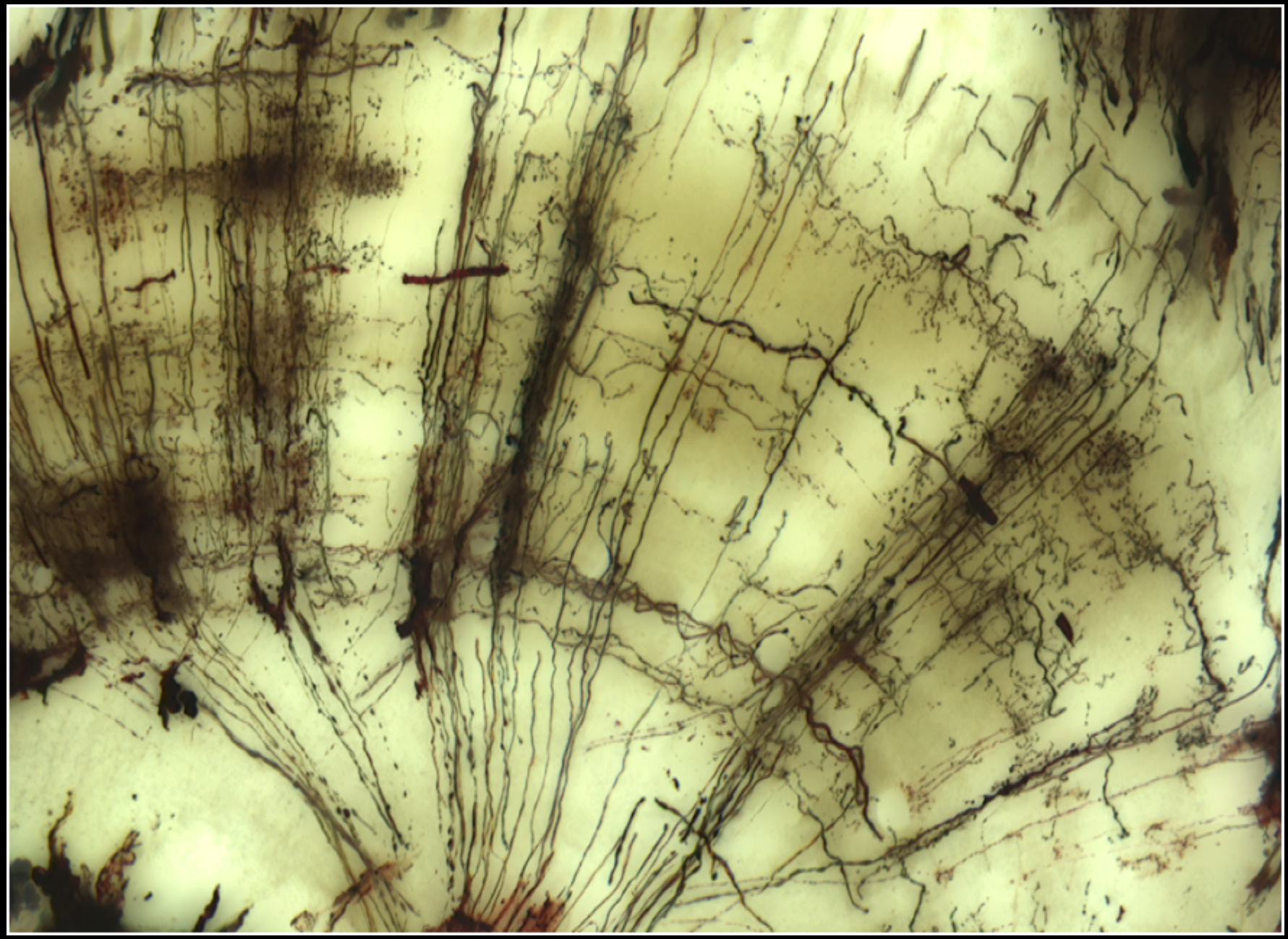


Medan et al. 2015 J. Neurosci

They are easily spotted even in unstained preparations



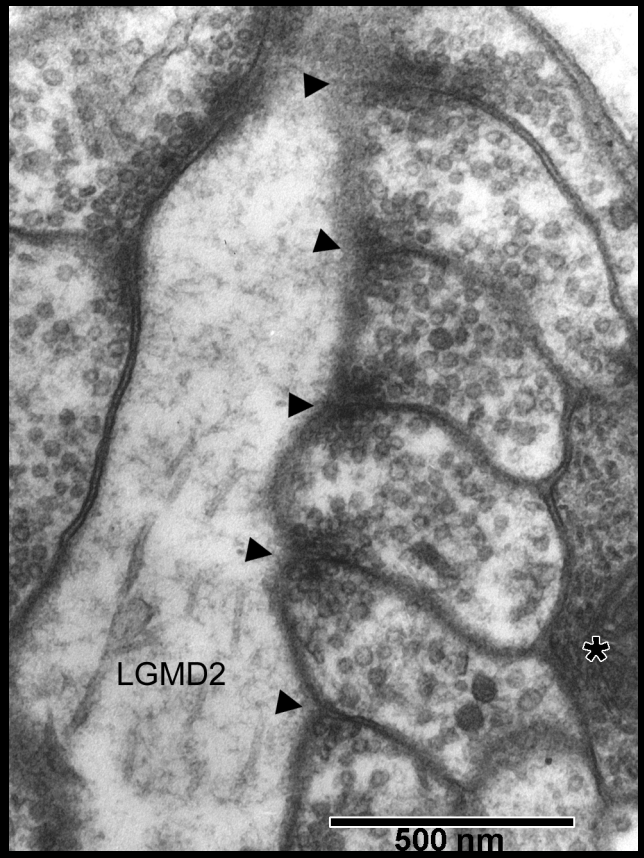
They are easily spotted even in unstained preparations



Locust- synapse organisation in looming detector neurons

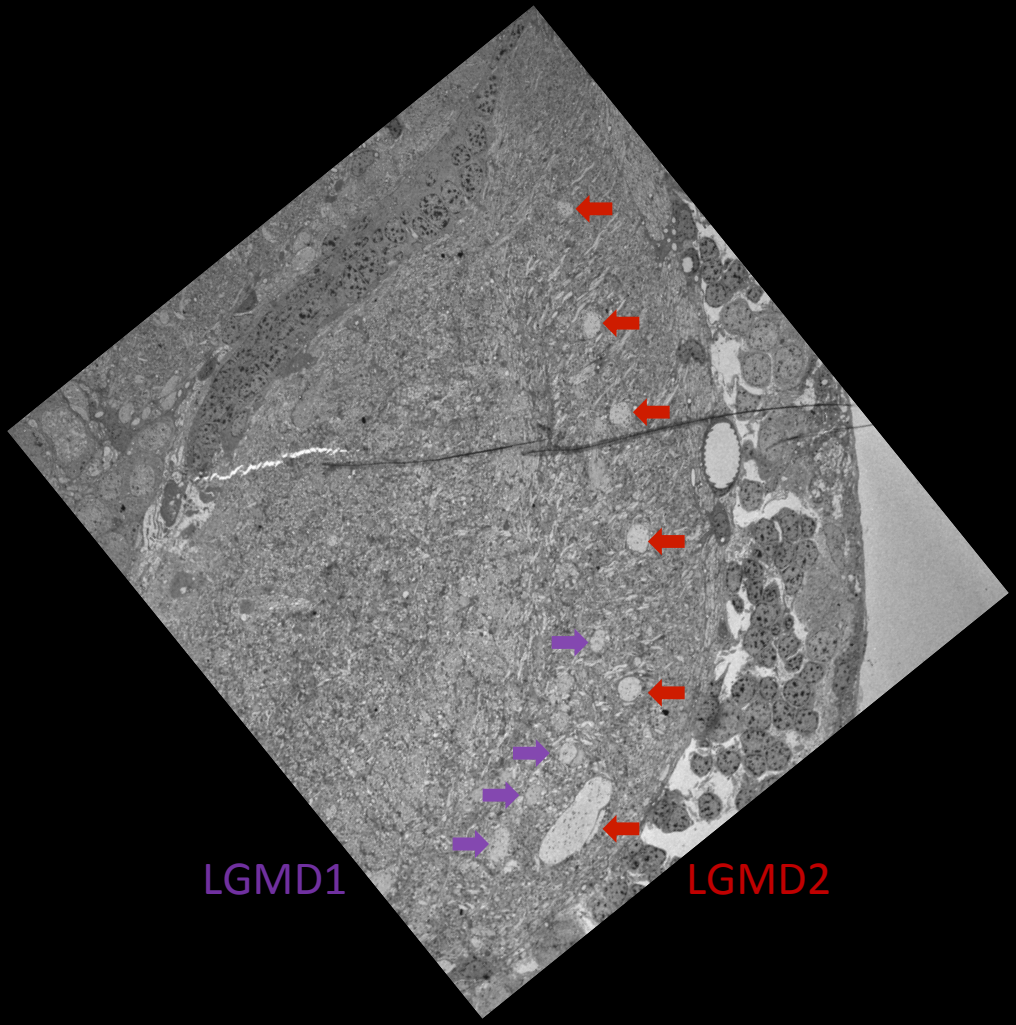
Both LGMD 1 and 2 show synapses that occur in pairs, with the presynaptic densities of neighbouring afferent processes lying adjacent to one other. In each case, one postsynaptic profile belongs to the LGMD and the 2nd to the neighbouring afferent process, which also makes synapses upon both the LGMD and the 1st afferent.

This organisation is thought to provide both the lateral inhibition and the excitation needed to explain the collision sensitive nature of LGMD neurons.



Rind and Simmons, 1998
Rind and Leitinger, 2000

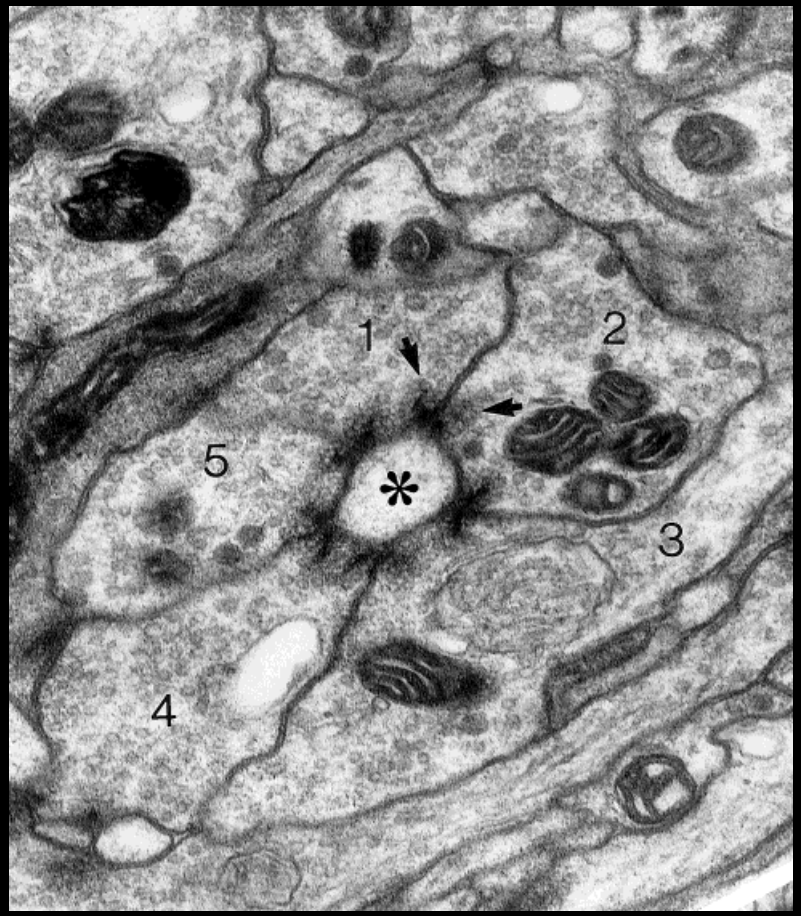
3rd instar locust:



We think that we can use unstained crab preparations where as in the locust, the big profiles of MLG1 neurons will be evident.

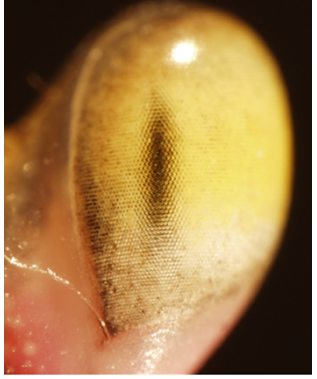
Yair Barnatan secondment plan:

Find out if the synaptic organization of the transmedullary neurons synapsing with MLG1 neurons reflects the diadyc configuration found for locust LGMDs.



Rind and Simmons, 1998






Vision

Object detection

Self-generated optic flow

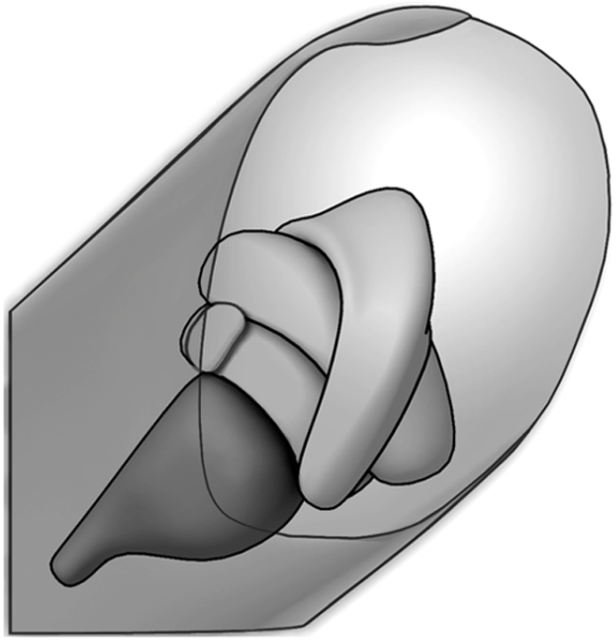
Optomotor responses

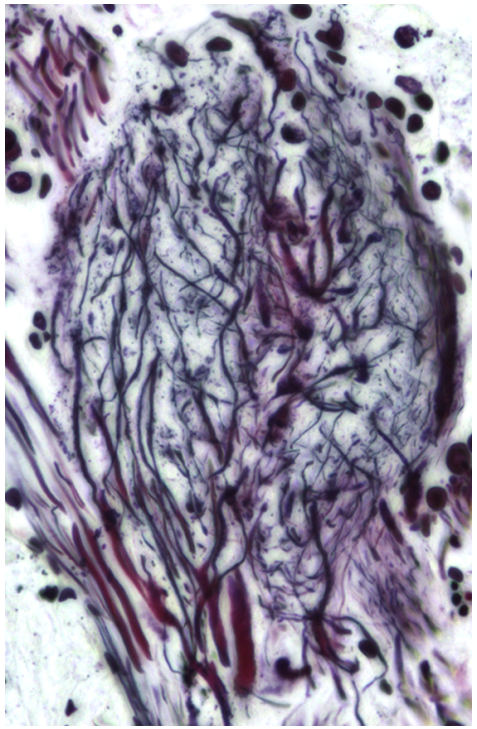
Course control


No Fixation 60.17


20s

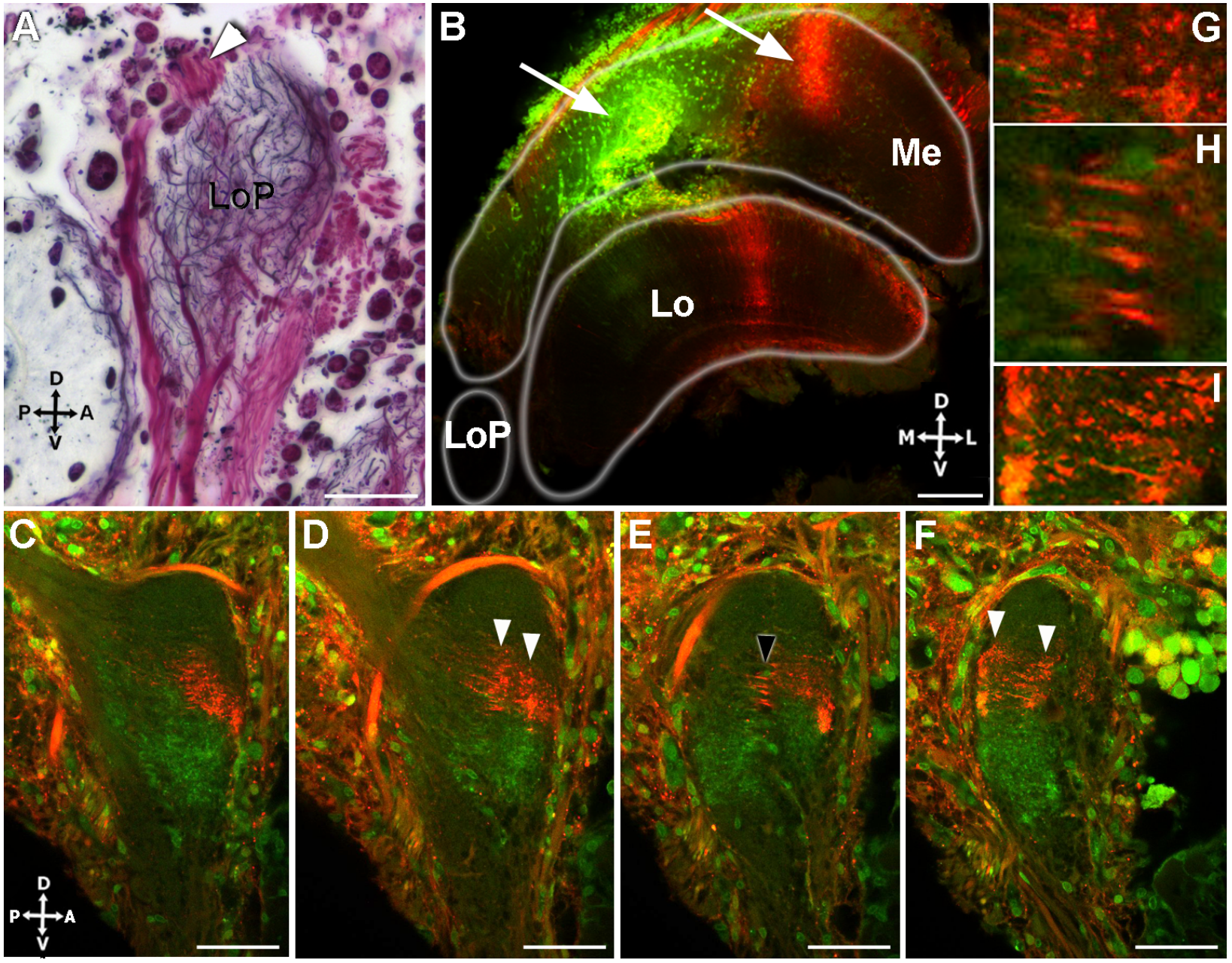
In flies the brain area involved in optic flow analysis and in commanding optomotor responses and course control is the lobula plate.



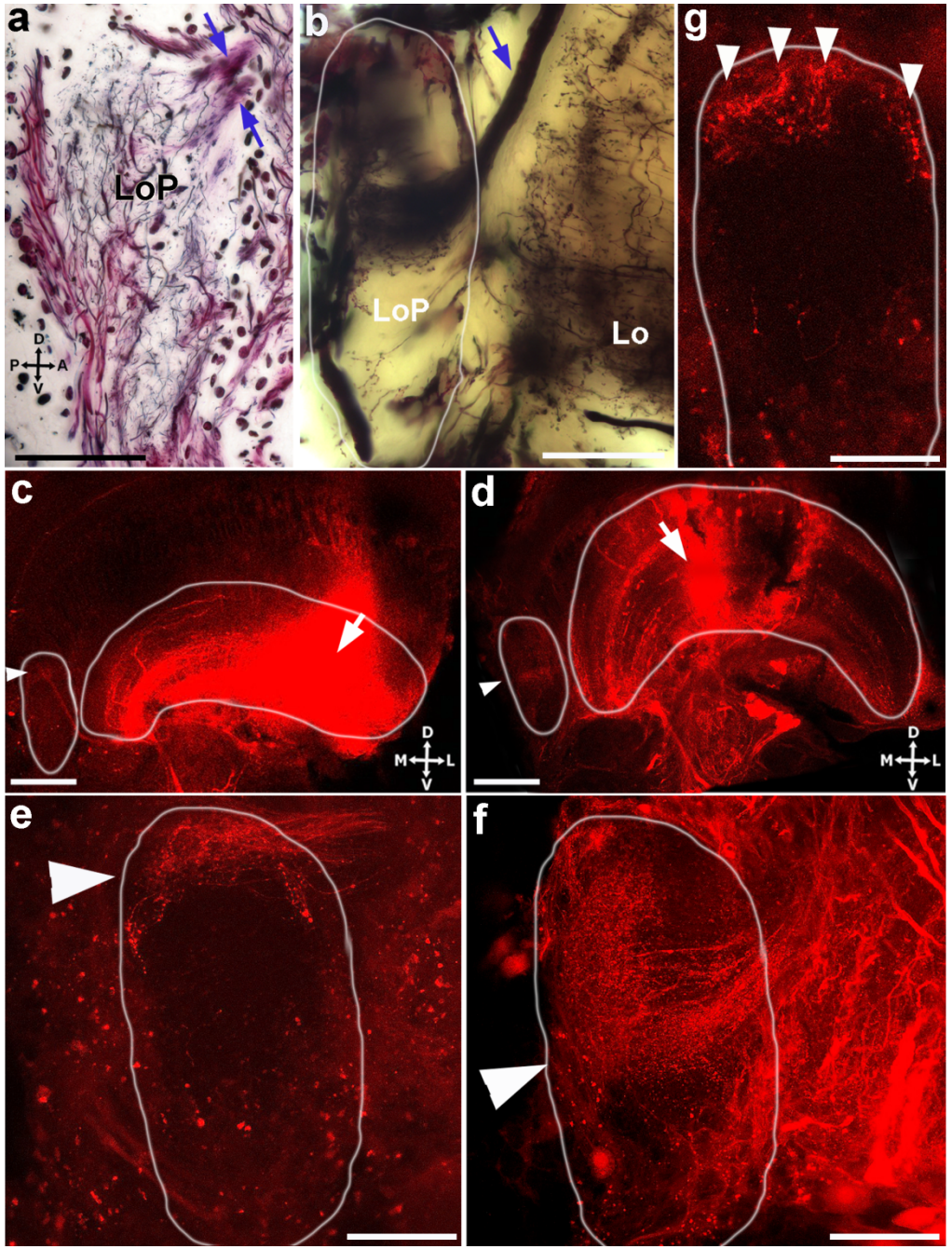


Bengochea, Berón de Astrada, Tomsic & Sztarker. J Comp Neurol 2017

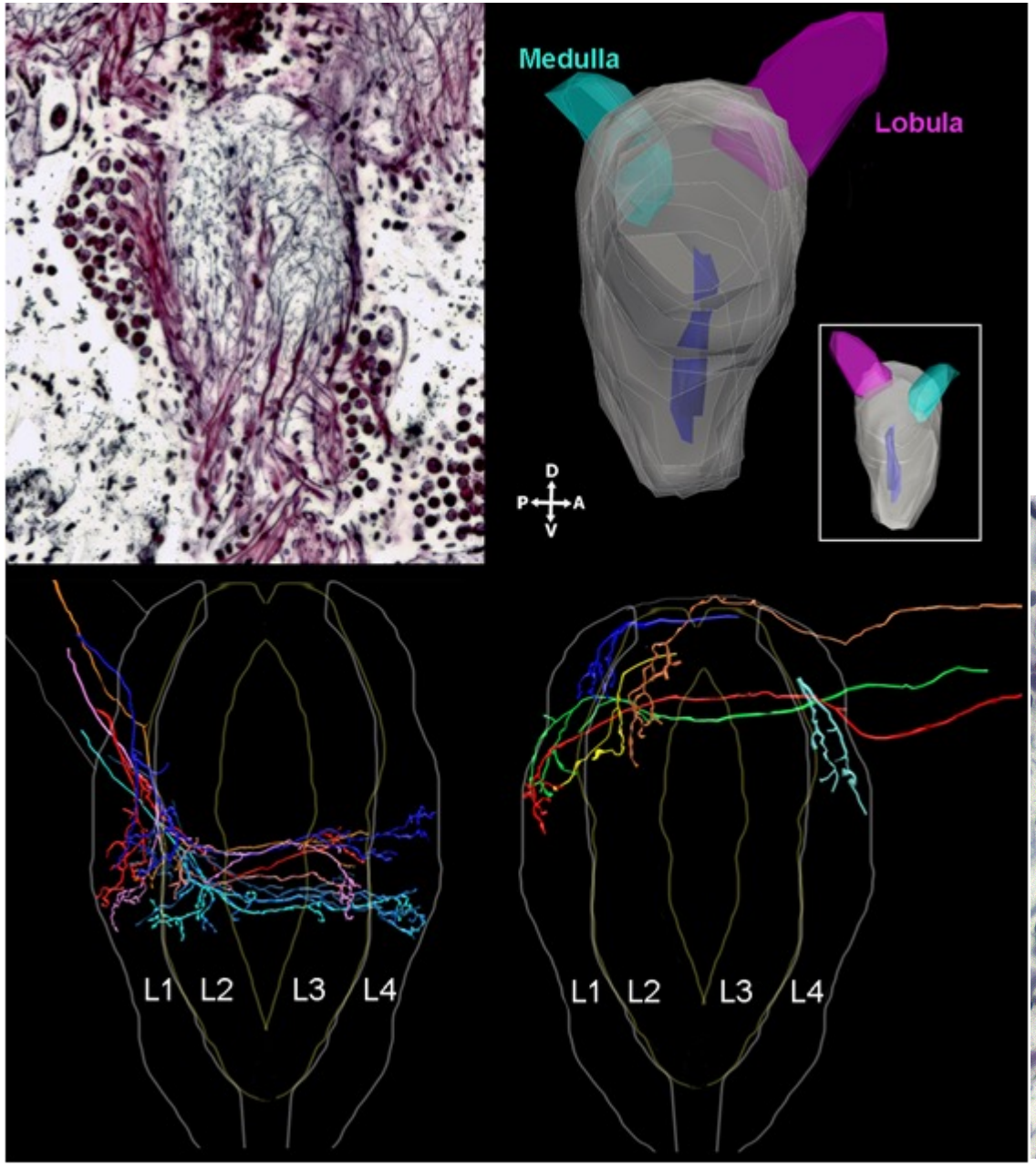
Retinotopic inputs from the medulla



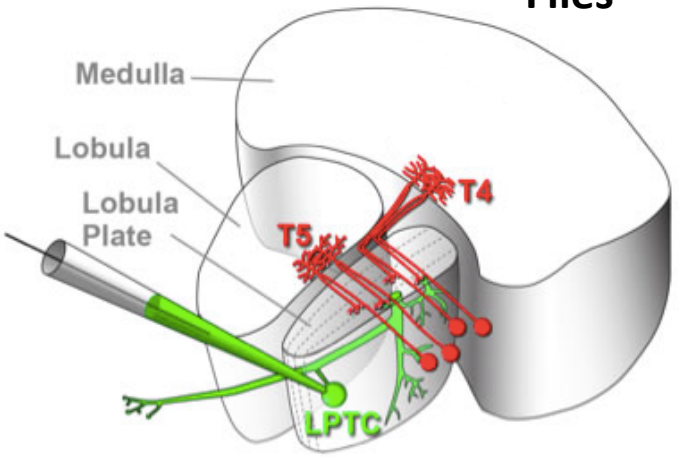
Retinotopic inputs from the lobula



Crabs

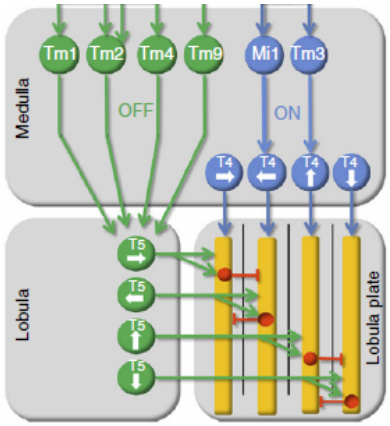


Flies



Bengochea, Berón de Astrada, Tomsic & Sztarker. J Comp Neurol 2017

From a functional perspective:



•In flies there are 4 functional layers, each responding to one of the four cardinal directions

Calcium imaging experiments

•In flies, the lobula plate tangential cells (LPTC) involve an horizontal and vertical system each represented by different cells.

Electrophysiology: intracellular recordings and staining

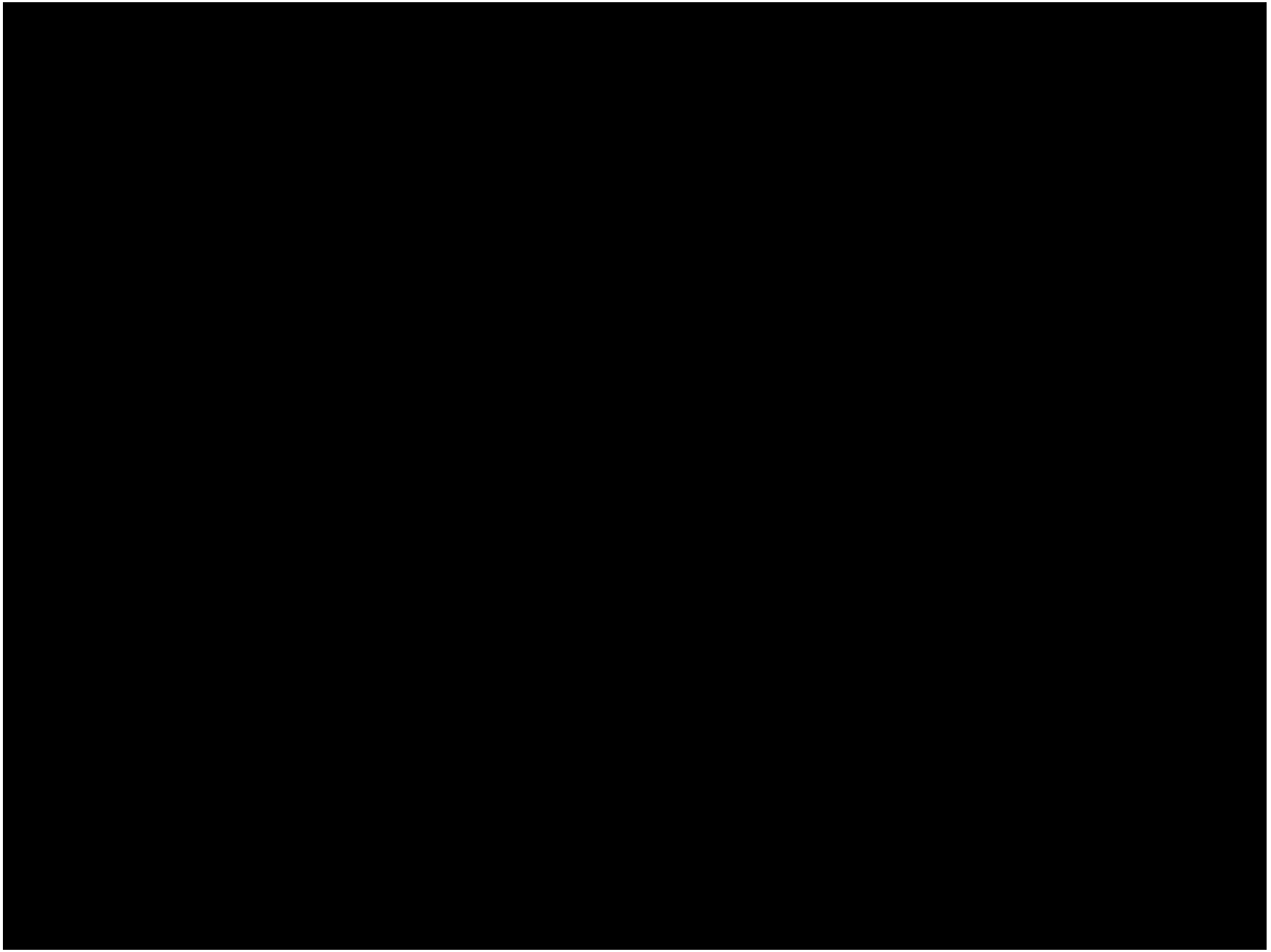
•LP has been related to the performance of optomotor responses and to course control

Ablation experiments (evaluate optomotor responses in ablated and sham animals)

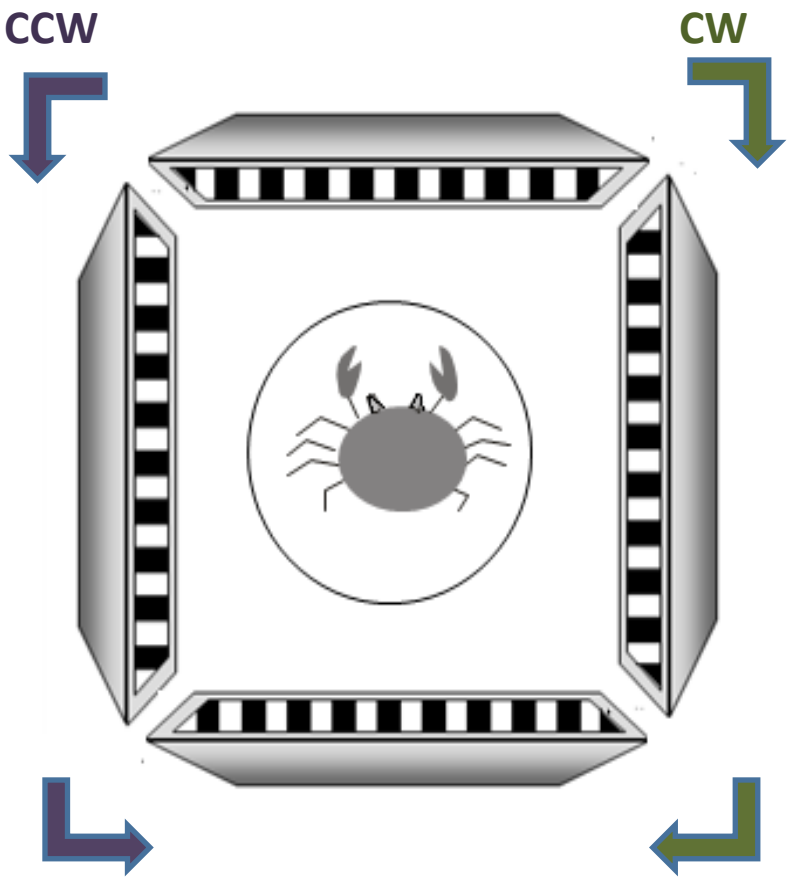
Behavioral experiments evaluating optomotor responses in crabs

If eyestalks are glued in a fixed position crabs perform optomotor responses by rotating with the whole body (easily recordable).

We then occluded the vision of one eye or the other by using a removable cap.

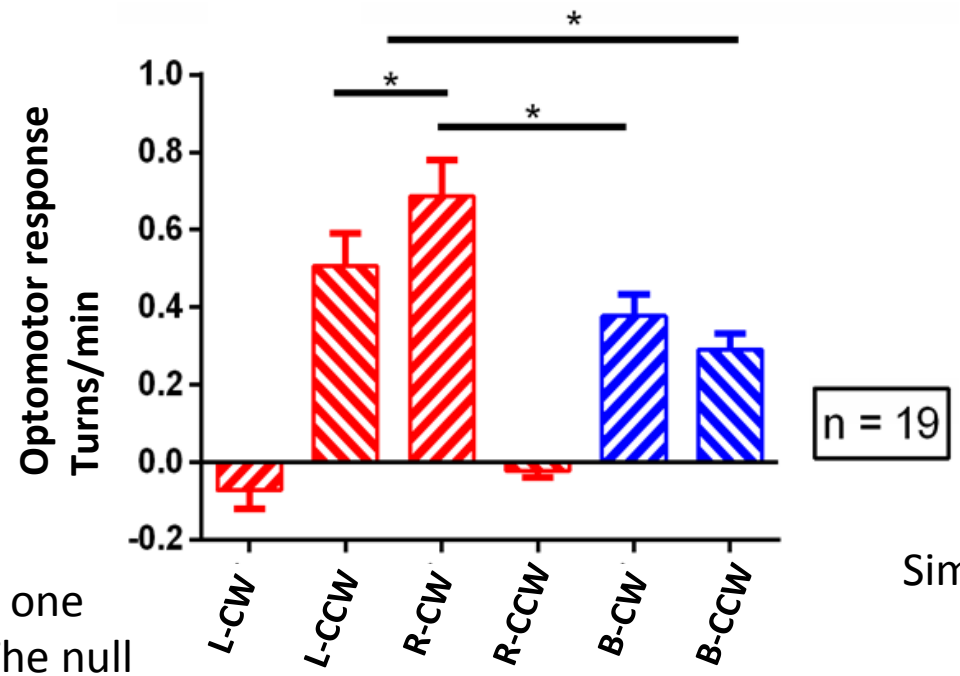


Virtual stimulation with an optic flow pattern



Virtual stimulation with an optic flow pattern

L= left eye
R= right eye
B= binocular
CW= clockwise
CCW= counter clockwise

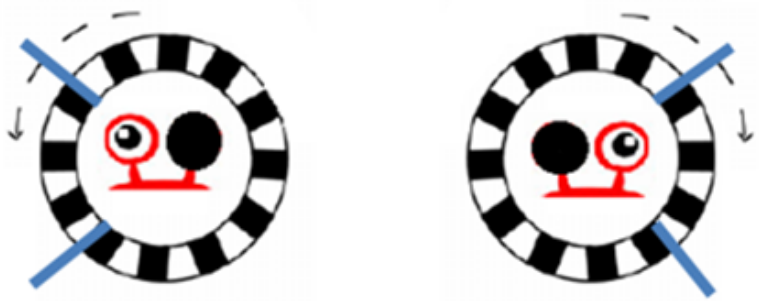


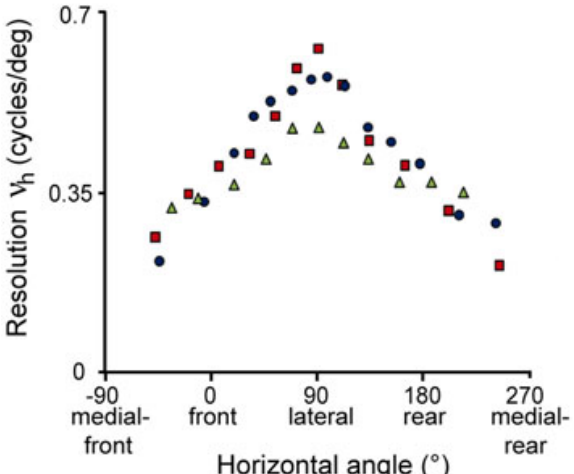
Binocular responses are less intense than monocular responses

For each eye, there is one preferred direction. The null direction leads to errors.

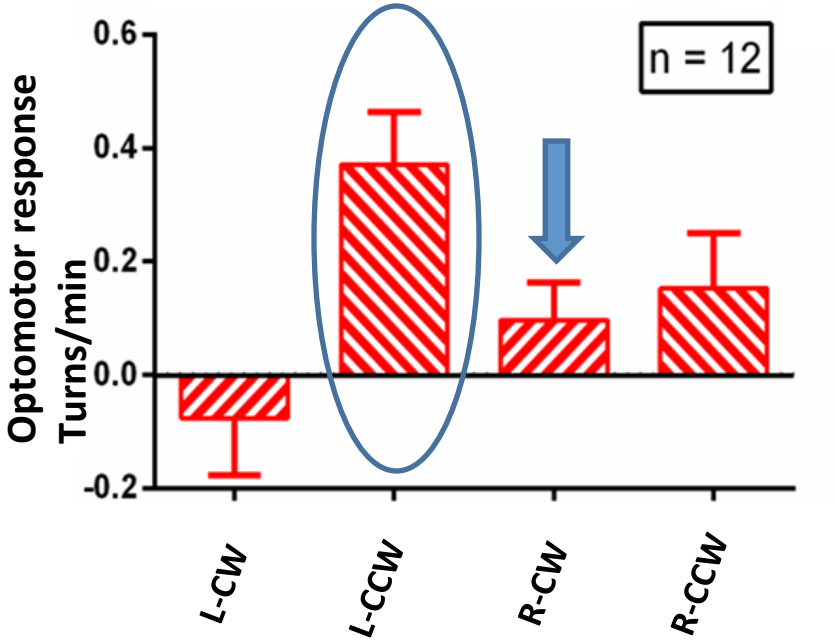
Similar phenomena were found in Drosophila. Duistermars et al 2012

High responses in monocular crabs are to front to back movement (FTB) in the ipsilateral field of view

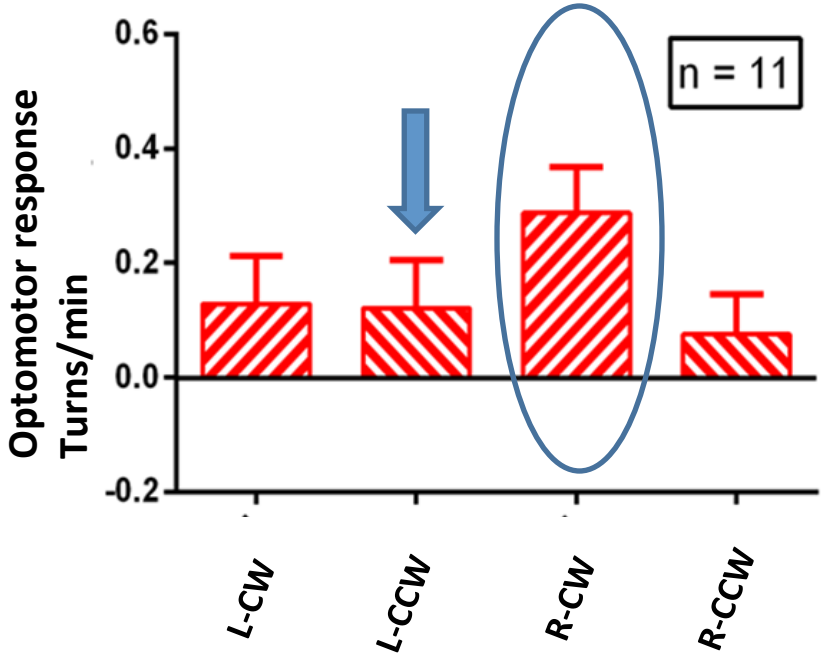




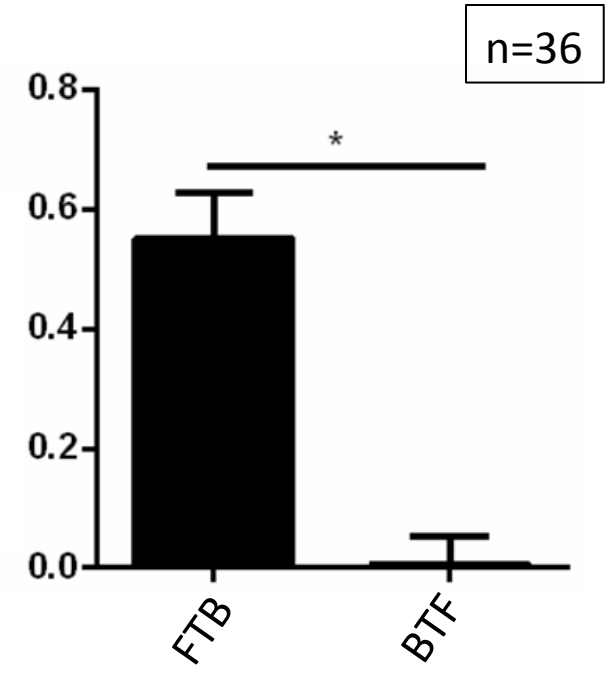
Left-handed



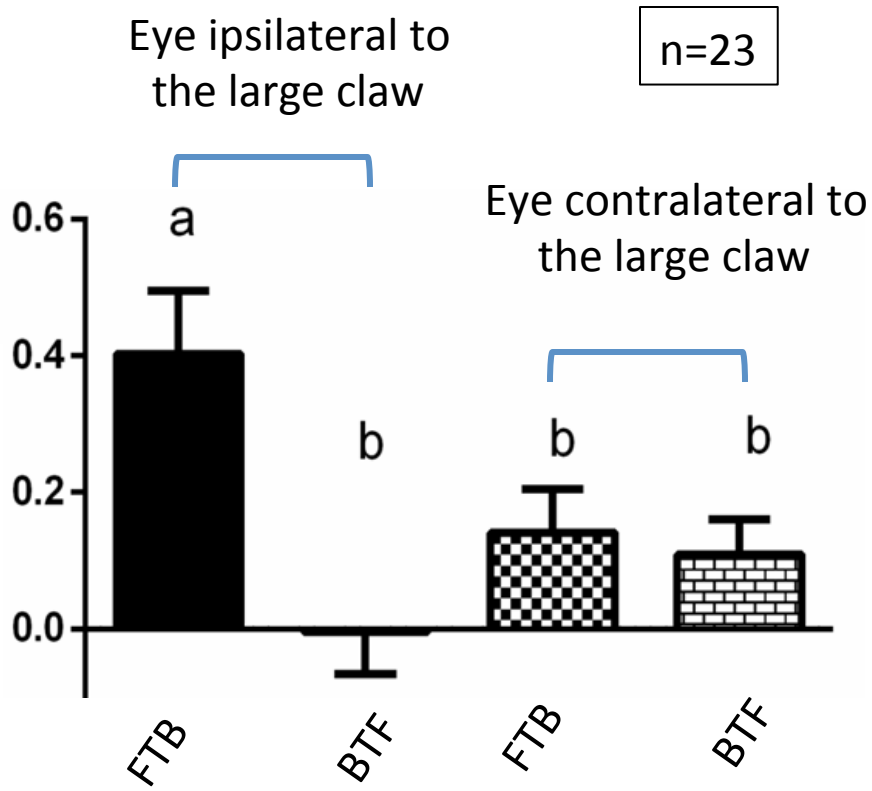
Right-handed



Neohelice

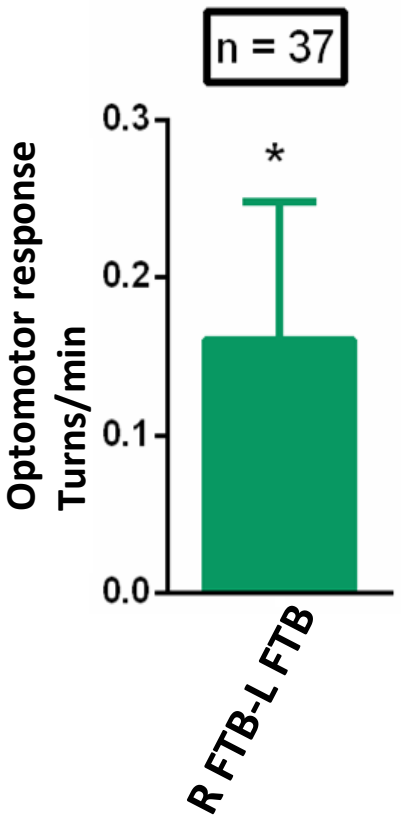


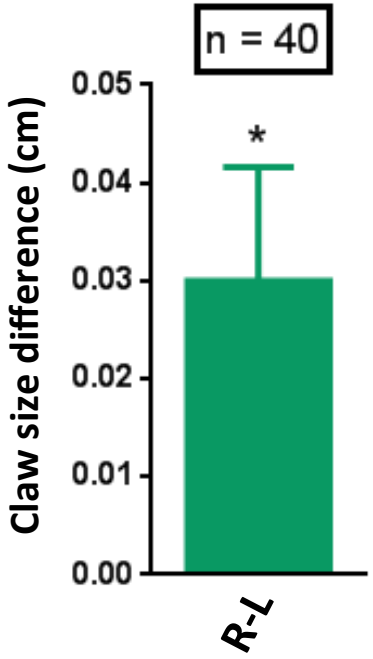
Uca



Clear eye dominance corresponding to the large claw

Eye dominance in *Neohelice*: in all the experiments right eye driven OR were stronger



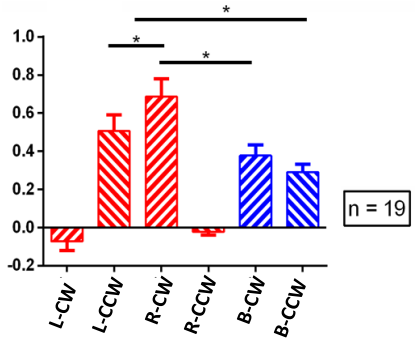


Is there any correlation between dominance and claw size?

Monocular vision

Preferred → **High OR**

Null → **Null OR**



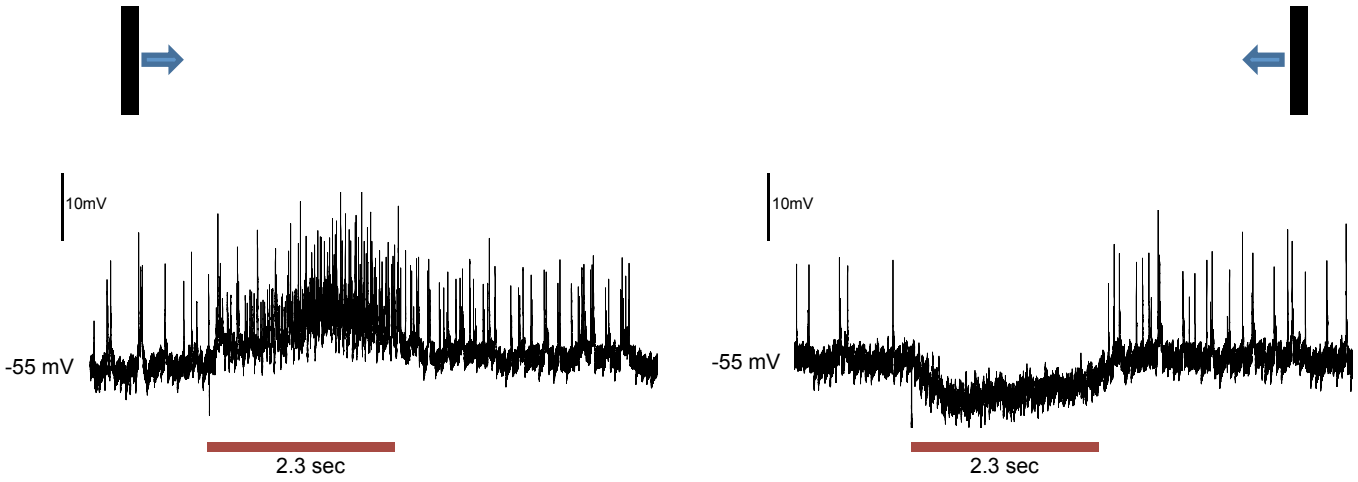
Binocular vision

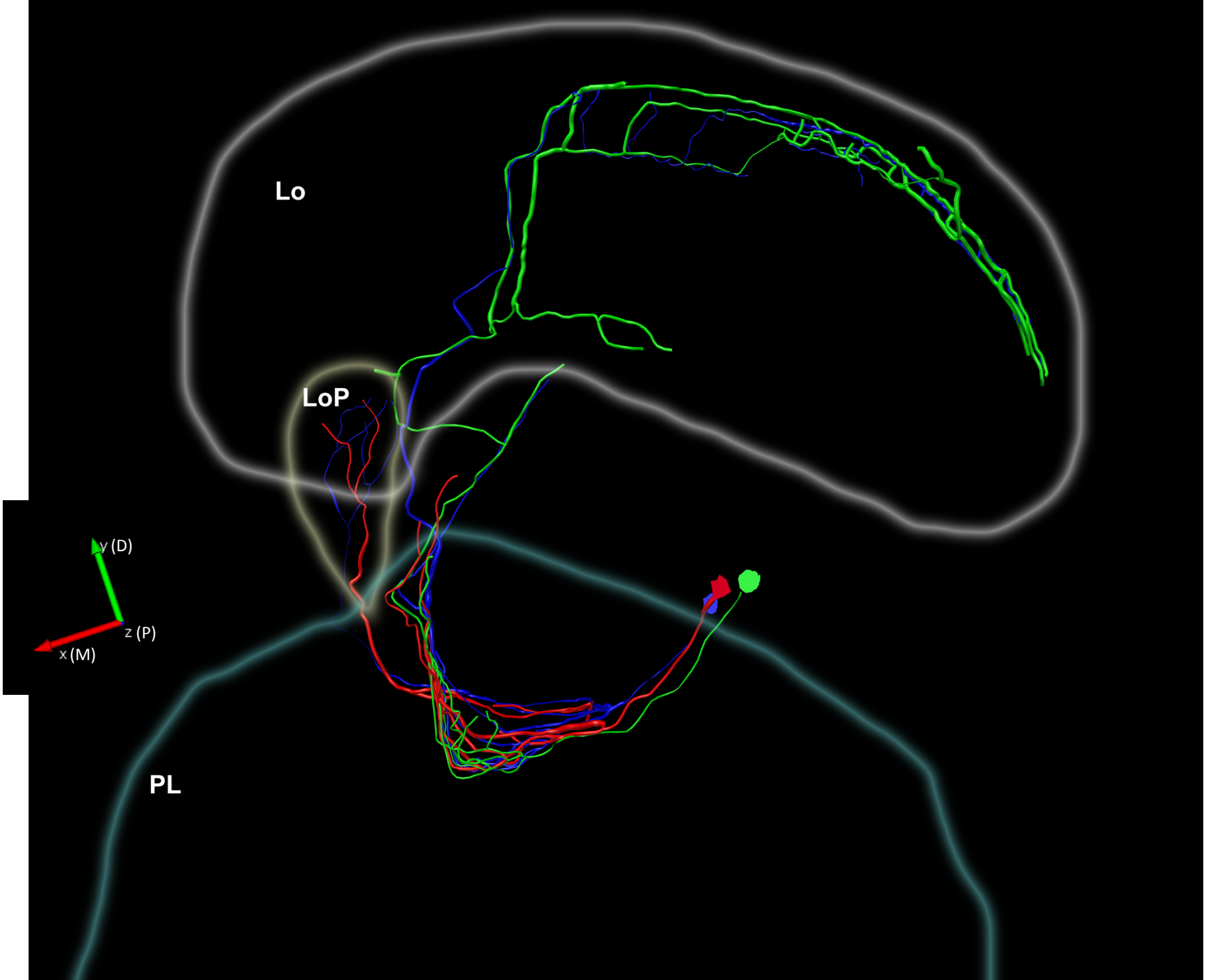
→ Null +preferred → **Moderate OR**

To explain these results we propose that the centre integrating and commanding optomotor responses should receive information from direction selective neurons responding to FTB motion as preferred stimulus .

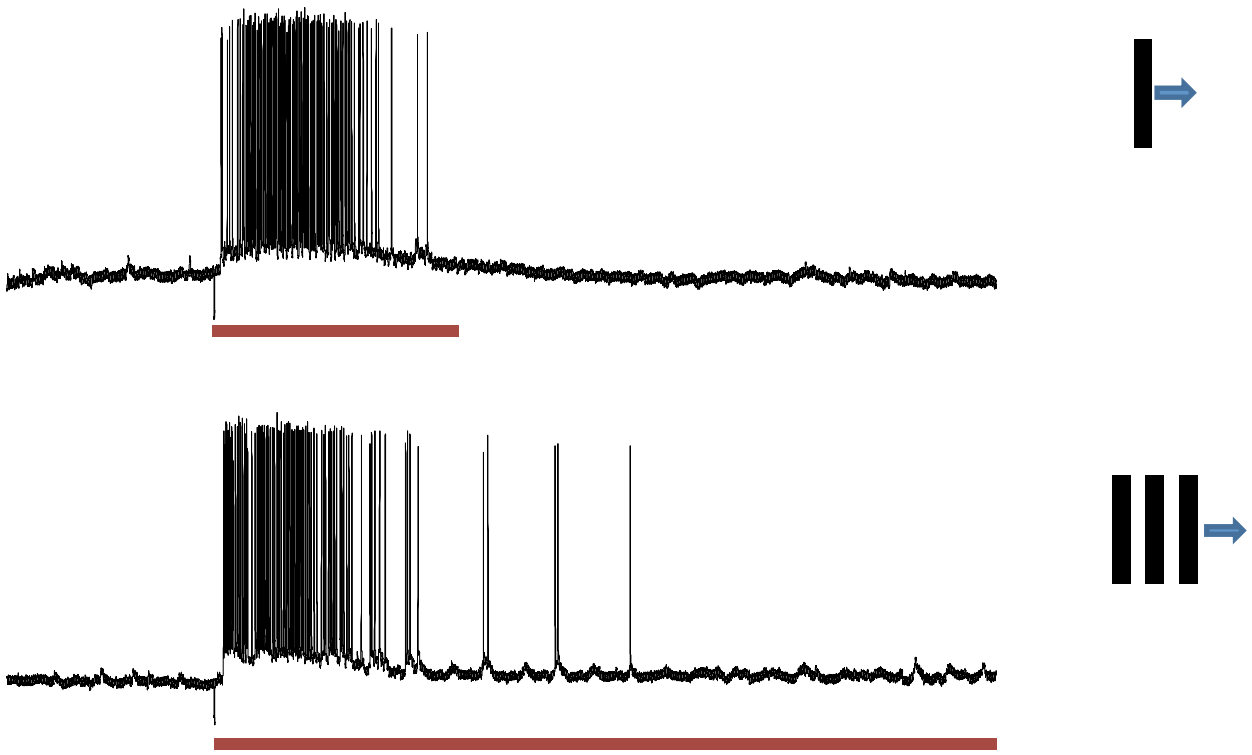
Direction selective neurons (ipsilateral receptive field)

Single bar (right monitor)

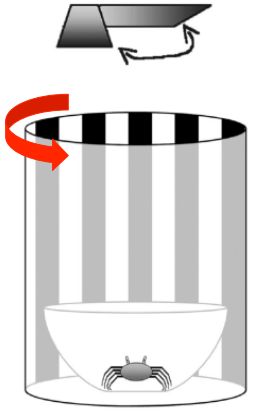


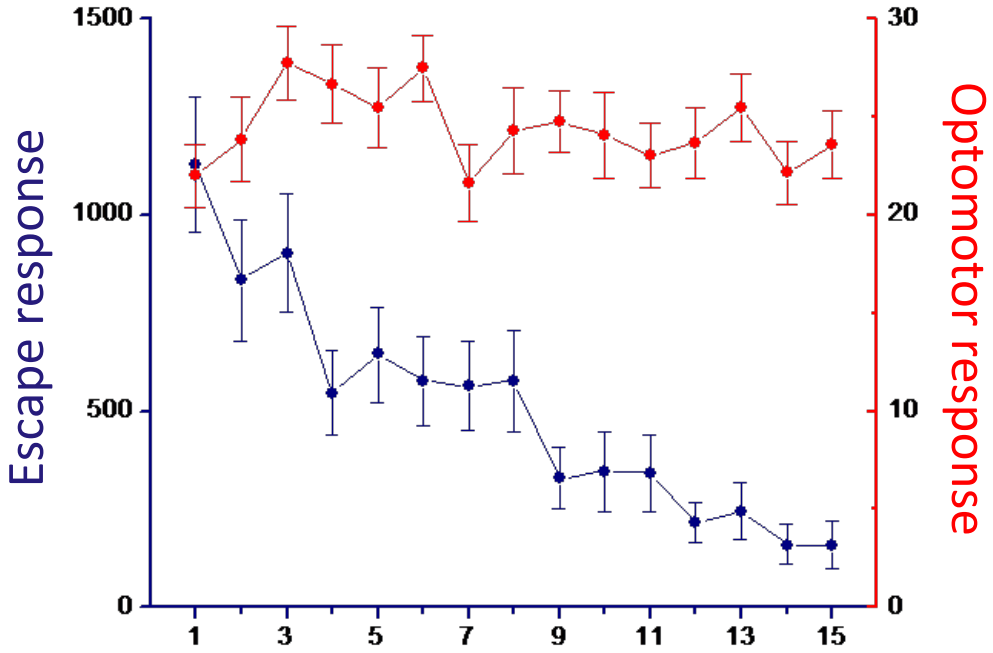

Lo
LoP
PL
y (D)
z (P)
x (M)

But these neurons don´t respond steadily to wide field motion



Plastic vs sustained response

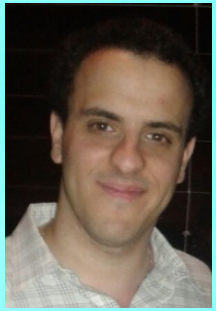




We are planning to record neurons from our candidate region to be involved in optic flow analysis (the lobula plate) to see if we can find directional neurons with strong responses to wide field motion and sustained responses.

Yair Barnatan
Florencia Scarano
Mercedes Bengochea
María Grazia Lepore

Martín Berón de Astrada
Daniel Tomsic






Laboratory of Neurobiology of Memory

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